Indian and Northern Affairs Canada
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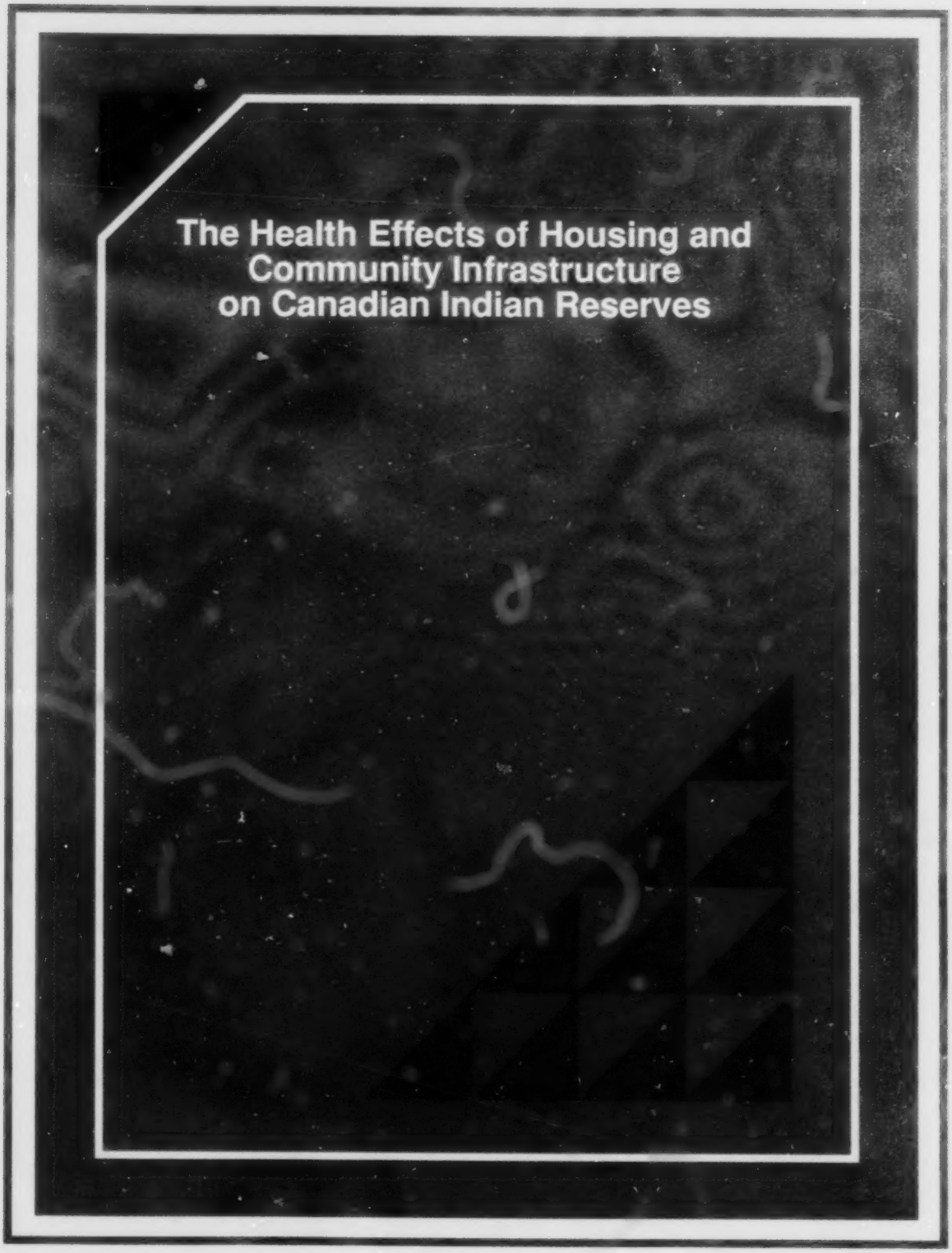

The Health Effects of Housing and Community Infrastructure on Canadian Indian Reserves

Canada

THE HEALTH EFFECTS OF HOUSING AND COMMUNITY INFRASTRUCTURE ON CANADIAN INDIAN RESERVES

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under contract for

Quantitative Analysis and Socio-demographic Research
Finance and Professional Services
Indian and Northern Affairs Canada

August, 1991

Published under the authority of the
Hon. Tom Siddon, P.C., M.P.,
Minister of Indian Affairs and Northern Development

QS-3505-000-EE-A1

Catalogue No.: R72-224/1991E
ISBN 0-662-1906-4

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Cette publication est également disponible en français sous le titre:

Les effets du logement et de l'infrastructure communautaire sur la santé dans les réserves indiennes du Canada

92-069 59/

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EXECUTIVE SUMMARY

The poor health status of on-reserve Indians in comparison to Canadians nationally is well recognized and has been repeatedly demonstrated in research studies and official statistics. Much of the excess mortality and morbidity has been attributed to substandard housing and infrastructure, although a causal relationship has been difficult to demonstrate. The present paper conducts a critical and comprehensive review of the literature on the health impact of housing and community infrastructure. In addition, minimum standards for housing and community infrastructure compatible with health and safety are suggested.

Research studies, some of which have been conducted on reserves, have shown that a variety of health problems are associated with poor housing conditions. These include infectious diseases, non-infectious respiratory diseases such as asthma, chronic conditions, and injuries. A summary of results from numerous studies are found in Table 7.2 on page 32.

The evidence suggests that crowding is one important factor in health. Rates of respiratory, skin and eye infections and tuberculosis, meningitis, and measles have been found to be higher in crowded households. Similarly, hospital admission rates for intestinal, skin, and middle ear infections, as well as burns also appear to be related to crowding. Crowding may be even a greater threat to mental health than to physical health. As crowding has been shown to contribute to inter-personal conflicts within the family and community, housing might be linked to the high suicide and homicide rate.

Central heating is a second health factor. In one study, for example, reserves with the highest proportion of homes having central heating showed lower respiratory disease admission rates to hospital for young children. Also, microbiological organisms can be found in improperly maintained heating and ventilating systems and in wet or damp rugs and furnishings, which can cause upper respiratory symptoms and allergic reactions.

Studies linking water supply and sanitation to specific health outcome are summarized in Table 8.1, page 43. Although there is a lack of adequate studies, the weight of the evidence is in favour of the beneficial health impacts following improvements in water and sanitation. Studies have demonstrated that as water consumption increases, intestinal and skin infections decrease. While quality is important, high standards are unrealistic in many locations and should only become a priority after improvements in excreta disposal and water quantity have been achieved.

Indoor air quality is influenced by combustion processes, building products, the amount of fresh air that circulates, and the size of the house (the smaller the house the higher the contaminant level). For example, wood burning stoves which are prevalent on reserves emit several pollutants which have been linked to respiratory infections.

In terms of safety, natives have one of the highest accidental and violent death rates in the world. Part of this reflects inadequate housing and community infrastructure. The excessively high mortality rate from house fires could be linked to unsafe wood stoves, lack of safety devices in the home, and inadequate fire protection services in the community.

Based on the literature, the author speculates that the high drowning rate may be due in part to faulty boat safety practises and lack of instruction. Easy access to firearms probably contributes to the high rate of firearm deaths.

A short and practical checklist on housing standards in relation to health and safety is the Minimum Requirements for Health in Native Housing used by Health and Welfare. These requirements, listed on page 73, include such variables as water supply, sewage disposal, crowding, temperature, and humidity. However, as the author points out, it is important to realize that establishing and working towards a set of minimum standards for housing and community infrastructure may not address psychosocial health issues. Good health is the physical, mental and social well-being of individuals, and all of these factors must also be considered in relation to housing. Maintenance of cultural values related to spirituality, socialization of children, respect for elders, and kinship obligations are important to health promotion. Thus, along with minimum housing and infrastructure standards, housing that is conducive to good health should also consider: architectural and aesthetic qualities of housing which reflect cultural values; physical location of houses in communities affecting social interaction patterns; and issues of home ownership and cost of maintenance in relation to local economic and cultural values.

... I am greatly astonished that [the white men] have so little cleverness ... in the effort to persuade us to convert our poles, our barks, and our wigwams into those houses of stone and of wood which are tall and lofty, according to their account, as these trees. Very well! But why now, do men of five or six feet in height need houses which are sixty to eighty? ... Do we not find in our own all the conveniences and the advantages that you have with yours, such as reposing, drinking, sleeping, eating and amusing ourselves with our friends when we wish? ... Hast thou as much ingenuity and cleverness as the Indians, who carry their houses and their wigwams with them so that they may lodge wheresoever they please, independent of any seigneur whatsoever? Thou art not so bold nor as stout as we, because when thou goest on a voyage thou canst not carry upon thy shoulders thy buildings and thy edifices. Therefore it is necessary that thou preparest as many lodgings as thou makest changes of residence, or else thou lodgest in a hired house which does not belong to thee...

Speech of an Indian Chief, from Le Clerq's Nouvelle Relation de la Gaspésie, 1691. Cited in Koerte (1974).

PART ONE INTRODUCTION

1. Introduction

The poor health status of Native Indians in comparison to other Canadians nationally is well recognized and has been repeatedly demonstrated in research studies and official statistics. Much of the excess mortality and morbidity has been attributed to the low socioeconomic status, inadequate sanitation facilities and substandard housing. Although conceptually appealing and plausible, the causal relationship between poor housing, community infrastructure and health outcomes has been difficult to demonstrate. The available scientific evidence is often conflicting, inconsistent and inconclusive.

There is an extensive international literature, much of which is based on studies conducted in developing countries with a tropical climate where both the pattern of ill health and residential environment are quite different from the Canadian Indian reserve experience. There is also an older literature dating to the 1930s and 1940s in the developed countries, but its relevance to today's Indian reserves is not always evident. While there is no dearth of data on Indian housing and on Indian health, to-date very few studies have been conducted on Canadian Indian reserves to address specifically the causal relationship between housing and health. Of those that have been done, most are in the form of unpublished or limited distribution consultant reports, government documents and dissertations.

A critical and comprehensive review of the literature on the health impact of housing and community infrastructure has important implications for policies and programs directed at Canadian Indians. Such a review is timely since both the Canadian public at large and members of Indian communities are demanding immediate, visible and effective action to redress a major social inequity in Canadian society. The federal government's Green Plan released in 1990 called for major initiatives in improving environmental quality on Indian reserves. This was followed by the joint announcement in March 1991 by the Minister of National Health and Welfare and the Minister of State for Indian Affairs of a 6 year $275 million program to improve water supply and sewage disposal on Indian reserves.

2. Review Objectives

The objectives of this review are:

(1) To summarize, appraise and evaluate the existing literature on the impact of housing and community infrastructure on health and safety;

(2) To determine appropriate minimum standards of housing and community infrastructure compatible with health and safety;

(3) To identify policy and program issues relevant to Indian reserves in Canada.

The focus of this review is on Indian reserves in Canada. Recognizing that studies specific to this population are limited, the review also encompasses studies conducted in other aboriginal communities in North America as well as access the more general, "global" literature. The appropriateness of generalizations from other populations and political jurisdictions to Canadian

Indian reserves needs to be carefully considered.

While the primary purpose of this review is to summarize and organize the existing literature, it also critiques the underlying assumptions, theories and models used in previous studies and assesses their methodological rigour. Particular attention is paid to the epidemiological evidence for causality between exposure to substandard housing and infrastructure and various health outcomes.

3. Methods and Data Sources

3.1 Definitions

"Housing" is commonly understood to refer to the dwelling where human beings reside and conduct various activities, either individually or in some sort of group. The American Public Health Association [APHA](1969) defined housing as:

> the living unit for man and his family, the immediate surroundings, and the related community services and facilities; the total being referred to as the "residential environment".

The World Health Organization [WHO](1961) conceived of housing as:

> the physical structure that man uses for shelter and the environs of that structure including all necessary services, facilities, equipment and devices needed or desired for the physical and mental health and the social well-being of the family and individual.

In international development circles, the phrase "human settlement" has been in vogue for some time, and is in fact the name of a United Nations agency - the Nairobi-based UN Centre for Human Settlements or Habitat. In this report, terms such as "housing", "residential environment" and "human settlement" are used interchangeably, although in reviewing the literature, it is convenient to discuss conditions inside the dwelling separately from those affecting the neighbourhood.

Community infrastructure, in its broadest sense, can incorporate a full range of physical facilities and social activities that take place in a community - eg. sanitation, recreation, schools, health services, transportation, telecommunication, energy, fire protection, law and order, businesses, industries, agriculture, and so on. This report discusses in detail a more restricted list to cover those aspects which have a direct effect on health.

The definition of "health" is more problematic. The much quoted World Health Organization definition that health is a state of complete physical, mental and social well-being and not just the absence of disease and infirmity is useful in broadening the perspective on health beyond that of the traditional "medical model" to include psychosocial factors. However, it offers little to those intent on measuring health. In research studies, it is still by far the commonest practice to measure health in terms of death, disease, disability, discomfort and dissatisfaction, although increasingly more "positive" notions can be incorporated into survey questionnaire design.

3.2 Data Sources

The literature on housing and health is large and scattered among the biomedical, social science, planning, architecture, engineering and technical literature. Much of this is in the so-called "grey" or "fugitive" literature categories (unpublished or difficult-to-obtain government documents, consultants' reports, etc). No attempt was made to search this literature systematically.

As a starting-off point, various published bibliographies have proven extremely useful, such as the bibliography of Native housing compiled by Canada Mortgage and Housing Corporation (Canadian Housing Information Centre 1988). The bibliography on housing and health published by WHO (Martin et al 1976) covers the international literature, including some of the historically important older literature. Several state-of-the-art review papers and monographs [eg. Feachem et al (1981), and Esrey and Habicht (1986) on the health aspects of water and sanitation; Martin (1967) and Smith (1990) on housing and health] provide a bibliographic guide to the relevant literature.

Extensive use was made of locally available resources within the University of Manitoba library system, and through inter-library loan, other libraries. The CMHC Library also supplied many useful items not available elsewhere. Specialized collections of materials on Native and northern health and on environmental health maintained by the Northern Health Research Unit and the Occupational and Environmental Health Unit respectively were consulted. The rapidly accumulating project file of reprints was supplemented by limited computer searches of on-line biomedical databases, particularly to ensure that no important recent relevant publications had been missed.

3.3 Organization of Report

In Part Two, the current status of housing and community infrastructure on Canadian Indian reserves is reviewed, based on statistical reports provided by the Department of Indian Affairs and Northern Development. This is followed by a brief overview of the pattern of health and disease among Canadian Indians. Finally, the few studies conducted in aboriginal communities in North America which specifically attempted to correlate housing conditions with health status are summarized and critiqued.

Part Three provides a selective review of the international literature on the health effects of housing conditions and crowding, water supply and sanitation, indoor air quality, and safety hazards. For each topic area/hazard an attempt is made to:

* review the known/suspected health effects
* estimate the prevalence of exposure on Canadian Indian reserves
* estimate the burden of illness/suffering on Indian reserves
* identify existing interventions and assess data on their efficacy and/or effectiveness

Part Four discusses the development of the principles of healthful housing and the evolution of housing standards in Canada, the USA and the UN and its special agencies. A final section covers the social, economic and cultural aspects of housing which is particularly important in the context of Canadian Indian reserves.

Part Five concludes the report with a summary of the major findings and conclusions.

PART TWO HOUSING AND HEALTH ON INDIAN RESERVES

4. The Residential Environment

4.1 Sources of Data

Between 1958 and 1975 the Department of Indian Affairs and Northern Development conducted Biennial Housing Surveys [see for eg. Rahim 1976]. In 1977 the survey was entitled Housing Needs Analysis Survey. Much of the information from these departmental surveys was summarized and presented graphically in the widely distributed Indian Conditions document (DIAND 1980). The series of national and provincial reports on socioeconomic conditions published by the Department in the late 1970s and early 1980s also relied heavily on the 1977 survey [see for eg. Siggner 1979].

DIAND currently maintains several data systems on housing and infrastructure: the Capital Management Database, the Capital Assets Inventory System, and the Asset Condition Reporting System. The Census of Canada, conducted every five years, provide additional sources of data.

4.2 Housing Conditions

Traditionally, several major housing types were utilized by the aboriginal peoples of Canada. These included the snow house (igloo), the earth lodge and sod-earth house, the bark house, and the skin tent (Koerte 1974). While they have not entirely disappeared, traditional houses are no longer the major form of dwelling in aboriginal communities today. Instead, "modern" houses, particularly the single, detached structure, are the norm.

According to DIAND's special custom tabulations from the 1981 Census [cited in Clatworthy and Stevens (1987)], 93% of on-reserve dwellings were of the single, detached structure, compared to much lower proportions among off-reserve Indian (48%) and non-Indian (57%) dwellings in the country. On-reserve houses were generally smaller, with about half consisting of 4-5 rooms and about a third with 6 or more rooms. As a reflection of more recent government-sponsored construction programs, almost 80% of houses on-reserve were constructed during 1961-1981. However, recency of construction does not necessarily mean better quality.

The Census also allows the construction of various indicators of housing deficiencies. Fig.4.1, based on the 1981 Census, compares the prevalence of households inhabiting dwellings requiring major repairs, without indoor plumbing, without central heating and with more than 1.0 persons per room, commonly regarded as "overcrowding" in the Canadian context.

As expected, the prevalence of deficient housing was much higher on Indian reserves compared to the non-Indian population, with off-reserve Indians occupying an intermediate position. There was marked regional variation, with reserves in the prairie provinces and the northern territories faring the worst. In the Atlantic provinces, housing on Indian reserves tended to approach the levels attained by non-Indians.

Indian reserves in Canada are located in a variety of geographical settings. DIAND's Classification of Indian Bands by Geographic Zone (1983, rev.1984, cited in Clatworthy and

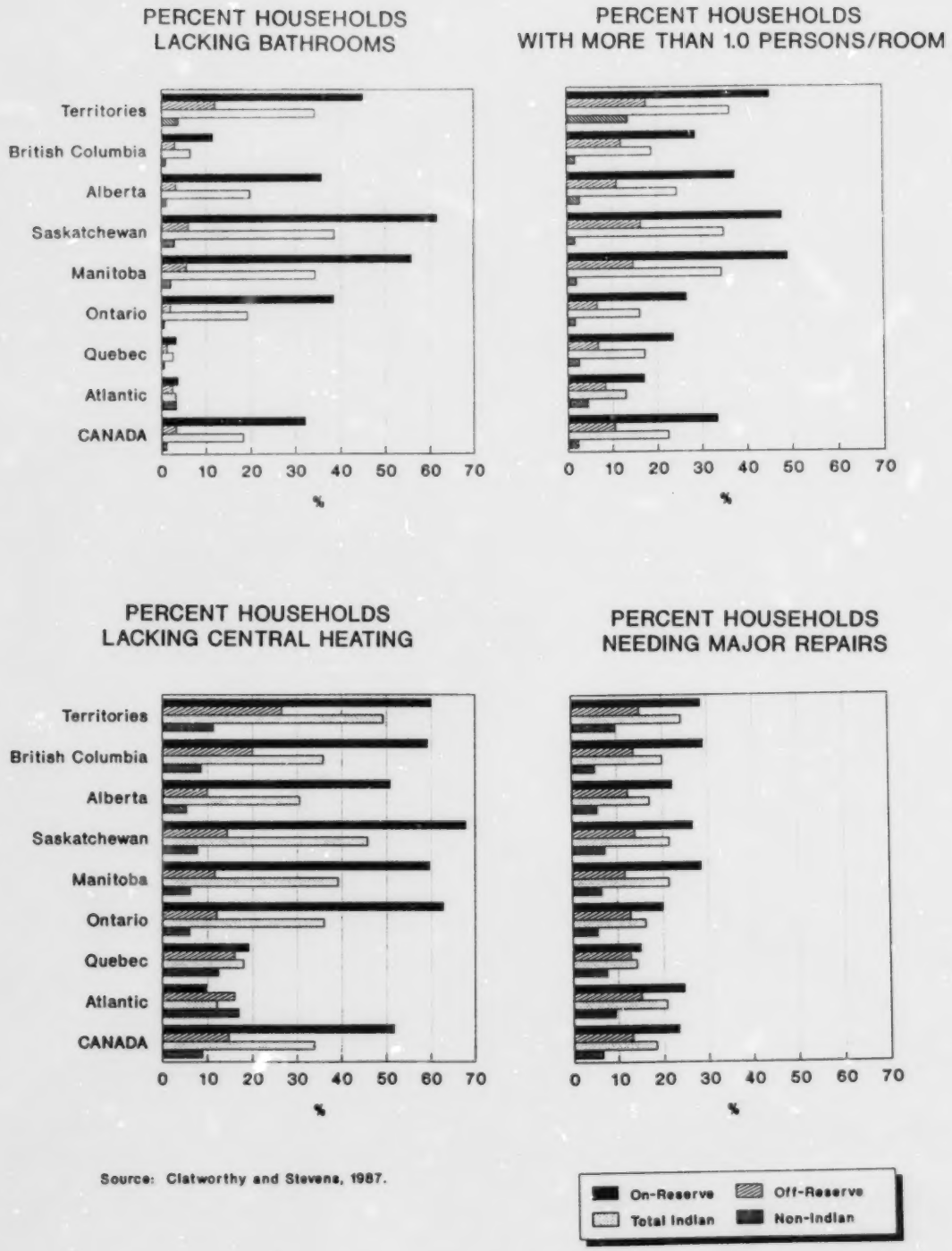


Fig.4.1 Housing Needs Indicators for Indian and Non-Indian Dwellings, by Region, 1981 Census.

Stevens 1987) is based on road access and proximity to regional service centres:

> Urban: within 50 km of nearest regional service centre with year-round road access
> Rural: within 50-350 km of nearest regional service centre with year-round road access
> Remote: over 350 km from nearest regional service centre with year-round road access
> Special access: lacking year-round road access

For the purpose of analysis, the "special access" category is often combined with the "remote". A gradient in terms of prevalence of housing deficiencies can also be observed, being highest among remote reserves and lowest among the urban (Fig.4.2).

Compared to DIAND's 1977 Housing Needs Analysis Survey, the 1981 data did demonstrate some improvements. One should, however, recognize that not all the definitions were strictly comparable. An example is the indicator "needing major repairs". The 1977 DIAND survey was based on assessment by a housing officer, whereas the Census was based on self-reports. Between the 1981 and 1986 Censuses, further improvements were evident. Fig.4.3 shows the regional data for central heating and crowding from the 1986 Census.

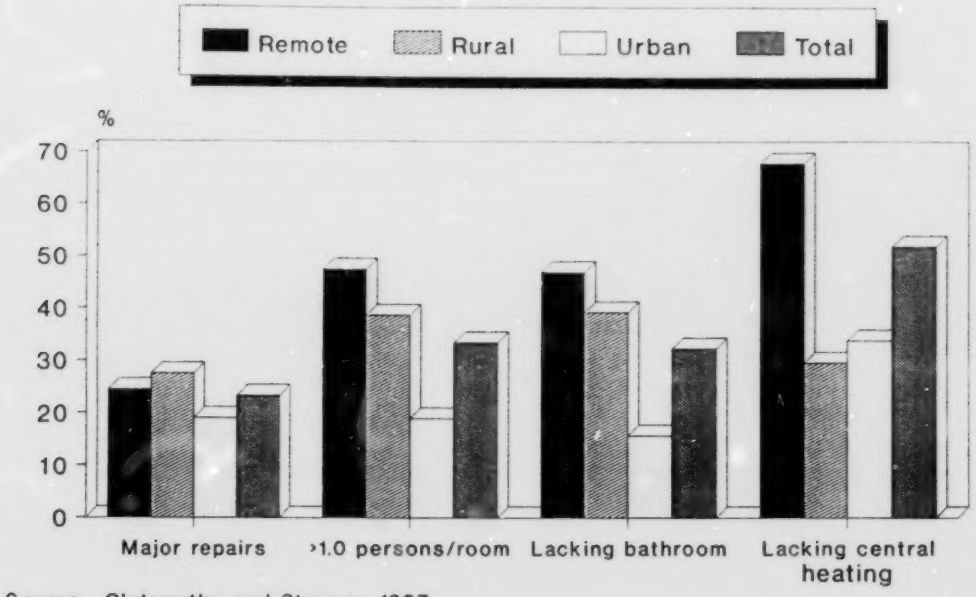
While indicators such as the state of repairs, presence of basic amenities and degree of overcrowding measure the adequacy and suitability of housing, the issue of affordability is more difficult to assess in the Indian reserve situation. The cost of providing shelter, proportion of household income consumed by housing needs, home ownership, rental and resale value, etc are generally not relevant, given the special legal trusteeship of Indian lands held by the Crown through the Indian Affairs Department and in some cases, collectively by the Band. However, recent initiatives in some areas to expand private ownership and/or the range of housing available through differential rental incomes has resulted in the need to review the "affordability" issue.

The already inadequate current housing situation was adversely affected by Bill C-31, an Act to Amend the Indian Act, passed by Parliament in June 1985. This act restores Indian status and band membership rights to large number of Indian women who had previously lost their status through marriage to non-Indians. By June 1990 the status Indian population grew by 19% in 5 years due to Bill C-31 alone. There was wide variation in the extent of increase in band size. Eighty percent of the bands had fewer than 150 new members attributable to Bill C-31. Much of the increase occurred off-reserve, although many bands believed that the full impact of Bill C-31 at the reserve level had probably not yet been felt. In response to the increased demand for housing, DIAND allocated supplementary funding to assist Bill C-31 registrants. Between 1986/87 and 1989/90, 2700 new units have been subsidized for Bill C-31 residents on-reserve and over $90 million of new funds injected into the regular housing program (DIAND 1990).

4.3 Community Infrastructure

In small remote communities, the installation, operation and maintenance of community infrastructure such as water and sanitation systems is dependent to a large extent on the physical environment - the terrain, soil conditions, drainage and climate. Permafrost poses a major challenge in Arctic communities but is less of a problem in the subarctic where it is discontinuous. Local geological factors such as the presence of outcrops of bedrock and the predominant type of surface deposits dictate the type of installation.

Table 4.1 presents a summary inventory of all Bands in Manitoba as on May 1990 to illustrate



Source: Clatworthy and Stevens, 1987

Fig.4.2 Prevalence of Housing Deficiencies according to Geographical Location of Indian Reserves, 1981 Census

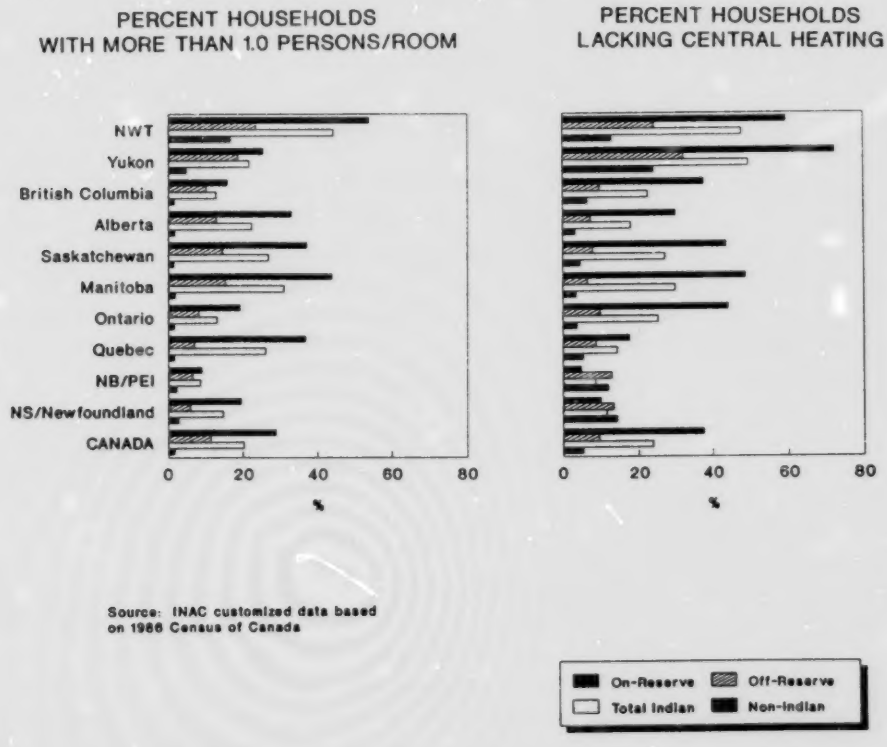


Fig.4.3 Housing Needs Indicators for Indian and Non-Indian Dwellings by Region, 1986 Census

Table 4.1 Inventory of Community Infrastructure on Manitoba Indian Reserves, 1990

	Percent of all	
	Bands	Housing Units
Water Supply:		
piped water	31	17.7
well water	38	14.4
water delivery	56	46.8
other	38	21.1
Sewage Disposal:		
piped sewage	23	11.8
septic field	56	23.4
septic truck	28	13.5
other	84	51.3
Electrification:		
grid	82	80.3
diesel generator	20	19.5
other	5	0.2
Solid Waste Disposal:		
adequate	66	65.2
self-haul	28	25.7
inadequate	13	9.1
Fire Protection:		
neighbouring community agreement	21	19.1
fire truck	52	56.6
minimal/no protection	29	24.3
Total Province	* 100.0	

Source: DIAND, Manitoba Region, unpublished data

Note:* a band is counted if the facility is available to, or used by any housing unit; total does not add up to 100% since categories are not mutually exclusive

the range in community infrastructure.

Water Supply: In the simplest case, individuals collect water from the nearest source (usually lake or river) by pail. In some communities a central standpipe system may be used to deliver treated water to one or several central points in the community where residents can collect it by pail. Water trucks may also be used to distribute water, usually from an existing standpipe system, to outlying areas where it is stored in individual tanks in the homes (tank size ranges from 200-450 litres). In some communities, treated water is delivered to every home. Rainwater as a source of water (via shallow troughs and collector drums) is little exploited. According to one consultant study in a northwestern Ontario reserve, 200-300 litres per house per month in the summer can be expected to be collected (Jackson et al 1979). The number of wells in existence vary from community to community. However, the proportion of protected wells (ie. concrete floor, heated shed) with operational hand pumps is often small.

The quality of surface water is poor in many respects. It is often grossly polluted with litter, gasoline from boats and airplanes, and effluent from defective sewage systems. Periodic testing of water samples taken from various access points by environmental health officers for bacteriological quality often shows unacceptably high coliform counts. Boiling and use of household bleach for purification are often recommended by health workers such as community health representatives and environmental health officers but data on the extent to which this is practised are lacking. In some communities, a small treatment plant performs simple chlorination, although instances of inadequate or undetectable chlorine residual are frequently reported. Many larger communities located near urban centres often have access to fully treated water.

The quantity of water consumed in each household is difficult to assess. In those northern communities without piped water supply and water-carried waste disposal, it has been estimated that 4-12 litres are used per capita per day (EPS 1979, cited in Campbell 1980). In the NWT, 45 lpcd is considered adequate for drinking, cooking, bathing and laundering purposes. According to Heinke (1980), the average water usage in households relying on self-haul is 10 litres per capita per day (lpcd); and 15-150 lpcd in those served by a truck system, depending on whether there is a pressure water tank and the type of toilet. With a piped system, water usage is around 200-300 lpcd, comparable to southern municipalities.

A report of the water delivery service in a northern Manitoba reserve indicated that there were enormous maintenance problems, especially in the winter (Huebert 1982). Each of the trucks was equipped with a 2400-litre water tank. The tank in one truck leaked, while the pump on another did not have the required horsepower to pump effectively. Both tanks and hoses required regular cleaning to prevent contamination. There was no garage facility to house the trucks when they were not in use. The water trucks served also as fire trucks and were kept full overnight. The homes that received trucked water stored it in 200-litre galvanized barrels. Contamination from the air and from continuous removal of water by various people, using various objects, was compounded by the fact that the barrels were not cleaned regularly. In another community the treated water supply was in jeopardy as a result of the lower lake level. Water was pumped to the lift station rather than gravity fed; it was chlorinated at the lift station after filtration rather than before; and there was not a rubber seal for the chlorine input line connector so that the filter acted as a site for bacterial growth. Inadequate water pressure was apparent at standpipes two km from the pump house. Vandalism, harsh weather and almost constant use contributed to the majority of standpipe breakdowns.

Sewage Disposal: Human excreta may be disposed of "dry" as "nightsoil" or "wet", when mixed

with water to become "sewage". In northern communities without indoor running water, the pit privy is the commonest method used. While this is a cheap and simple method to use, many of those that are in existence do not conform to standards and are often themselves sources of contamination of surface water supply. Another method commonly used is the bucket toilet or pail privy, called affectionately the "honey bucket", which basically consists of a plastic bag in a container. While cheap and easy to operate, the disposal of excreta-filled bags poses special problems. In winter they freeze to the ground or the garbage bins, leading to tearing. Improperly stored bags are attacked by dogs and ravens, scattering the contents in public places.

With the trend towards more dense settlement patterns, septic tanks and fields are used in many of the newer houses. Larger complexes (such as schools) may require multi-celled lagoons for settling and anaerobic decomposition of raw sewage. Soil permeability (determined by the relative proportion of sand and clay) is a key factor: a low permeability is ideal for lagoons but unsuitable for septic tank-leaching bed systems. The thin soil cover typical of many communities located in the Canadian Shield may result in sewage effluent reaching the lakes and rivers relatively untreated, resulting in bacteriological contamination. In very large communities piped sewerage systems have been constructed and a variety of treatment facilities used.

Solid Waste Disposal: The commonest methods used include burning, burying in garbage pits and disposal at landfill sites, although indiscriminate dumping is widely observed in many communities. Some bands own or contract garbage collection vehicles to provide service to individual homes. Landfill sites require proper maintenance which includes fencing, compacting and trench digging.

The amount of garbage generated by an individual in a remote, northern community is estimated to be 2 kg/person/day (Heinke 1980). Large quantities of metal cans, paper boxes, and plastic bags are brought into these communities and remain there for years.

Fire Protection: Many bands have formal or informal agreements with neighbouring municipalities to purchase fire-fighting services or provide mutual assistance. Some bands operate their own volunteer fire departments and water truck. Unfortunately the tragic consequences of non-operational fire fighting equipment in times of need are not infrequently reported. The number of fires on Indian reserves increased almost linearly throughout the 1970's and 1980's. The mean annual number of fires increased from 174 during 1970-79 to 295 during 1980-89. Annually about $12 million in property loss due to fires were reported during 1980-89 (in constant 1989 dollars). The most important causes of fires during 1980-89 were heating equipment 18%, arson or suspected arson 14%, electrical installation 13%, child related incident 11%, smoking 7%, grass and trash fires 6% (DIAND 1990).

Health Services: Health care in most Indian reserves in Canada is provided by the Medical Services Branch of Health and Welfare Canada. Several types of facilities are available, hospital, nursing station, health centre, health station, health office and clinic, depending on the size, staffing, equipment and functions. Table 4.2 summarizes the situation in Manitoba with regard to facilities in the community and access to the nearest hospital outside the community if none is locally available.

4.4 Government Housing Programs

Several federal agencies are responsible for housing on Indian reserves in Canada, the most

Table 4.2 Health Care Facilities For Indian Reserves in Manitoba

Indicator	number	(%) of bands
Distance to nearest hospital:		
0 - 45 km	17	28.3
46 - 90 km	18	30.0
91 - 135 km	10	16.7
136 - 180 km	8	13.3
> 180 km	7	11.7
Health care facility on reserve:		
Hospital	2	3.3
Nursing station	21	35.0
Health center/office	25	41.7
Health station/clinic	9	15.0
None	3	5.0
Mode of travel to nearest hospital:		
Hospital in community	2	3.3
Road	39	65.0
Scheduled air service	29	15.0
Air ambulance	10	16.7

Notes: *A nursing station is staffed by one or more nurses providing public health, treatment and short-term inpatient care;
*A health center and health office provides only public health services
*A health station is staffed by a community health representative supported by periodic visits by nurses and/or doctors

important of which is the Department of Indian and Northern Affairs (DIAND). DIAND's roles include providing capital subsidies for construction, acquisition, renovation and rehabilitation of houses; planning, technical assistance, inspection and training; and conducting demonstration projects in appropriate technology. Capital subsidies are administered by Band Councils or their delegated housing authorities, which establish local policies, allocate funds and implement housing projects. All houses built on reserves must now meet the National Building Code.

DIAND's subsidies are not intended to cover the full costs of a house. The Canada Mortgage and Housing Corporation, under the National Housing Act (R.S.,1985,c.N-11) operates two programs on reserves. One is the Rental Housing Assistance Program, under section 95 (formerly 56.1), a band-owned subsidized rental housing program which aims to reduce rental requirements to a level appropriate for low-to-medium income families. The second is the Residential Rehabilitation Assistance Program (RRAP), under section 51 (formerly 34.1).

Individuals also make contributions in the form of cash or labour. The Work Opportunity Program channels social assistance funds of people engaged in housing construction who would otherwise not be employed. Individuals are also eligible for on-the-job-training support from Canada Employment and Immigration.

Table 4.3 shows program statistics and expenditures between 1985/86 and 1989/90. It is evident that these statistics are impressive in terms of the number of, and the dollar amount associated with, houses constructed and renovated on reserves. However, the unmet need remains substantial.

An evaluation of DIAND's on-reserve housing program was conducted in 1984 by a private consultant firm. Based on a nationally representative sample of 94 bands and 1870 houses, the study involved home inspections and occupant interviews, as well as program management review at the local and national levels. While the inadequacy of current housing stock on reserve was once again confirmed [eg. 47% failed to meet basic standards of physical house conditions, 36% seriously overcrowded and 38% lacked some or all components of basic amenities], there was significant improvement compared to the 1977 Housing Needs Analysis Survey. The survey also found that dwellings where individuals had either contributed labour or capital, or been involved in the design, tended to be in much better condition than those where such individual involvement and commitment was absent. Bands which had relied exclusively on DIAND funding had not been able to achieve the same levels of improvements as those which had employed both DIAND and CMHC programs (Ekos Associates 1985).

In 1990 DIAND released Laying the Foundations of a New On-Reserve Housing Program, a discussion paper produced in consultation with the Assembly of First Nations, the Federation of Saskatchewan Indian Nations and the Dakota-Ojibwa Tribal Council. It identified the following problem areas:

(1) lack of Indian control
(2) inadequate supply
(3) poor quality
(4) high costs
(5) rising Band debt load
(6) lack of security of tenure
(7) insufficient economic and employment benefits

Table 4.3 DIAND Expenditures on Housing and Infrastructure, 1985/86 to 1989/90

	85/86	86/87	87/88	88/89	89/90
Number of Housing Units Constructed on Reserve	2831	2917	3068	3130	4259
Capital Expenditures for Housing ($ million)	79.6	83.2	93.8	108.4	138.2
Capital Expenditures on Community Infrastructure ($ million)	106.5	121.3	118.6	121.0	111.3
Operations Maintenance Expenditures on Community Infrastructure ($ million)	50.3	56.6	69.3	73.9	73.1

Source: DIAND

DIAND's Discussion Paper also mentioned the divergent view of housing between the federal government and some Indian organizations. The latter views housing as a right - treaty right, aboriginal right, and constitutional right. The former does not recognize any "universal Indian entitlement to government financed housing", only that it will provide financial support to Indian bands "at a level comparable to that available to other Canadians with similar housing and financial needs" (DIAND 1990). This is interesting in that it parallels the situation with regard to health services. The federal government also denies any treaty obligations to provide health services (notwithstanding the "medicine chest" clause of Treaty Six), but that it has done so since Confederation for humanitarian reasons, particularly in areas where provincial and private sources of care are not available (Young 1984).

While DIAND and CMHC are primarily concerned with the financing and construction aspects of housing and community infrastructure, the Medical Services Branch (MSB) of Health and Welfare Canada, through its environmental health officers (EHO), act as the approving health authority for such installations as septic systems and water supply. Its function is thus analogous to that of a municipal or provincial health department. There are no specific regulations which govern environmental health on reserves. The advisory and regulatory roles of the EHOs are not always clear cut, and they often see themselves more as educators than inspectors.

4.5 Housing on U.S.A. Indian Reservations

Since the passage of the Indian Sanitation Facilities Construction Act (PL 86-121) in 1959, the Indian Health Service has been constructing sanitation facilities for American Indian and Alaska Native homes and communities (USDHEW 1978). Despite the great strides, many families still lack basic facilities and thus are subject to various health hazards associated with such deficiencies. In 1987 the "unmet" needs were estimated to be $378.7 million for water, $180.5 million for sewers, $31.4 million for solid waste disposal, and $18.1 million for operation and maintenance, a total of $608.7 million (USDHHS 1988).

Although the US has had a federal Housing Act since 1937 which established public housing authorities, it was not until 1961 that the Department of Housing and Urban Development (HUD) decided that Indian tribes could participate in its housing programs. It took several years before HUD, the Bureau of Indian Affairs (BIA) and the Indian Health Service (IHS), in a Tri-Agency Agreement, agreed upon a joint approach to Indian housing. Indian housing authorities were created but there was little coordination or monitoring by the federal government. Many IHAs were poorly managed, grew too rapidly resulting in construction deficiencies, and went unaudited for years (Mills 1979). In 1974 a "Management Initiative for Indian Housing" was launched to address the administrative problems by providing tribes with training and technical assistance (Ormiston 1977).

In 1976 the Energy Conservation and Production Act (PL 94-385) was passed. Of direct importance to American Indians were the provisions of Title IV, dealing with energy conservation and renewable resource assistance for existing buildings (ie. weatherization and insulation). While states were the principal funding recipients, if low-income members of an Indian tribe were not receiving benefits equivalent to the assistance provided to non-Indian low-income persons in a state, the Federal Energy Administration was required to reserve from that state's grant a formula-determined sum for the eligible Indian tribe. While this program was triggered by the need to reduce national energy waste rather than by a direct concern for the well-being of those who occupied poorly insulated homes, it represented a new source for funding to improve Indian

housing (Schaller 1976).

5. Patterns of Health and Disease

The disparities in health status between Canadian Indians and the national population are well documented. Both government statistics (eg. Lithwick et al 1986, Department of National Health and Welfare 1988) and research studies (eg. Young 1988, Mao et al 1986, Beauvais 1989, Morrison et al 1986) point to a health gap in such indicators as infant mortality rate and age-standardized mortality rates in most disease categories. Yet, compared to several decades ago, the improvement has been substantial. Fig.5.1 shows the decline in infant mortality rate from the 1920s to the mid 1980s among Canadian Indians.

5.1 Demographic Trends

Figure 5.2 traces the rise and fall of Indian fertility in Canada from pre-World War II times to the present. According to demographer Romaniuk (1974, 1981), the increase in fertility during the early stages of the modernization period occurred as a result of the weakening or removal of biocultural inhibitions of childbearing in traditional societies - these include birth spacing, prolonged breast feeding, high pregnancy wastage and spousal separation. From the mid 1960s on the Indian birth rate began to decline.

The high fertility rate of Indians results in a "wide-based" pyramid, one which is typical of developing countries today or of Canada half a century or more ago (Fig.5.3). In the 1986 Census, 37% of aboriginal Canadians were below the age of 15 (compared to 22% of all Canadians), while less than 3% were over the age of 65 (10% among all Canadians). The predominantly "young" population has important implications for health care, housing, and socioeconomic development. This young population is the main contributor to the "dependency ratio" and places substantial demand on the service sector.

5.2 Causes of Mortality

The historical change in major causes of mortality among Canadian Indians is shown in Figure 5.4. The decline in infectious disease such as tuberculosis is particularly impressive (Figure 5.5). In a study of mortality on Indian reserves in seven provinces between 1977 and 1982, Mao and colleagues computed age-standardized mortality rates for coronary heart diseases (CHD), cerebralvascular accidents (CVA), lung cancer (LCA), and motor vehicle traffic accidents (MVTA) between ages 1 and 70 (Figure 5.6). The excessive mortality from motor vehicle accidents is evident. For chronic diseases - the so-called lifestyle diseases such as heart disease and stroke - the Indian rate has already overtaken the national rate in women.

5.3 Other Health Indicators

Mortality data provide only a limited view of the health status of the population, since not all health conditions result in death. Hospital morbidity - the causes of hospitalization - is often used to supplement mortality data. In Canada, status Indians are identifiable in the provincial health insurance claims databases in only a few provinces, namely BC, Alberta, Saskatchewan and

Fig.5.1 Decline in Infant Mortality Rate among Canadian Indians and Canadians 1925-1984

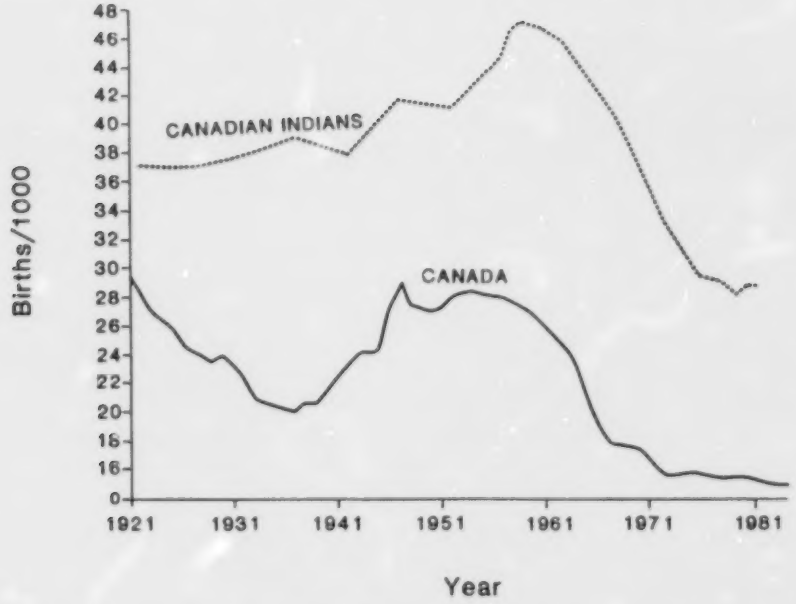


Fig.5.2 Change in Crude Birth Rate among Canadian Indians and Canadians, 1921-1984

[Source: Reproduced from Young (1988)]

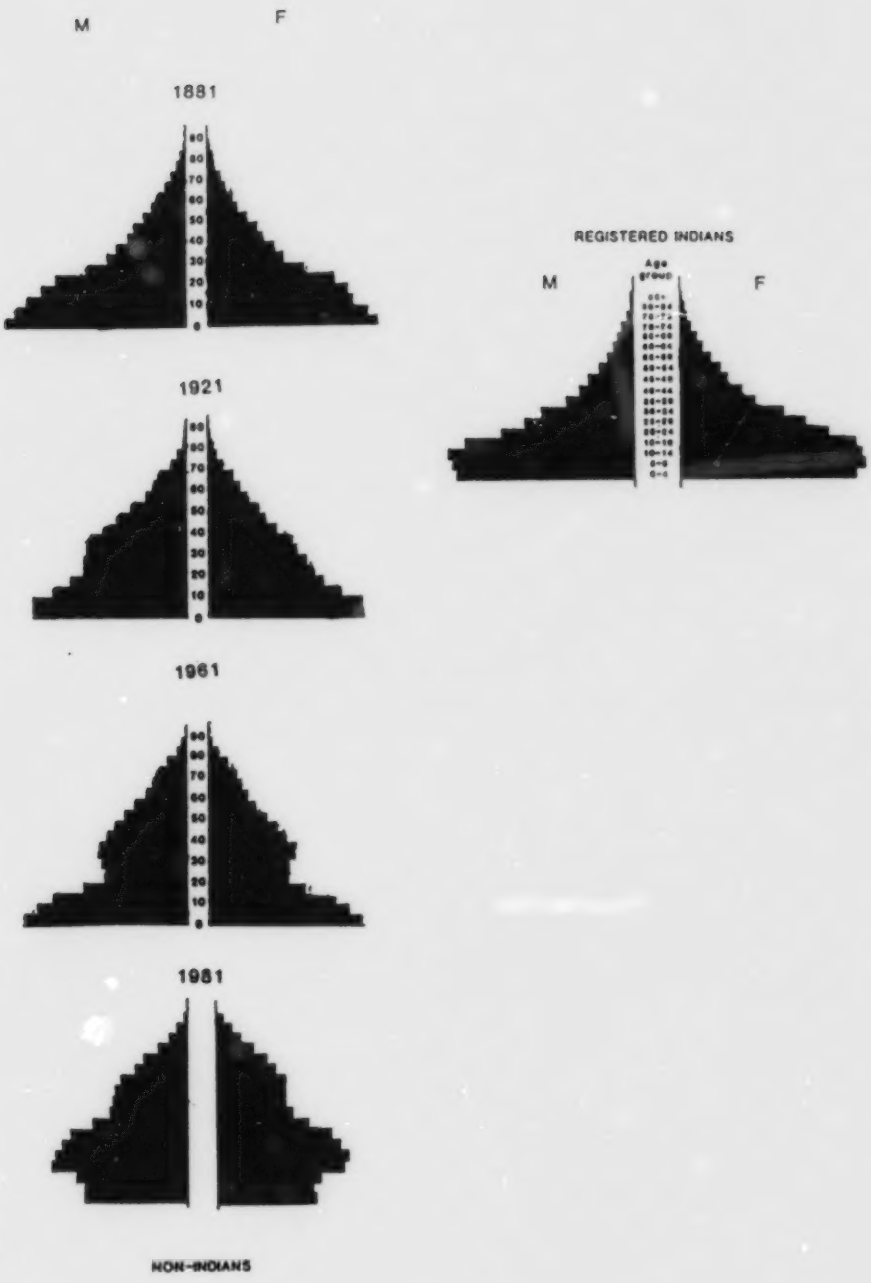


Fig.5.3 Population Structure of Canadian Indians and Canadians, 1981 Census

[Source: Reproduced from Young (1988)]

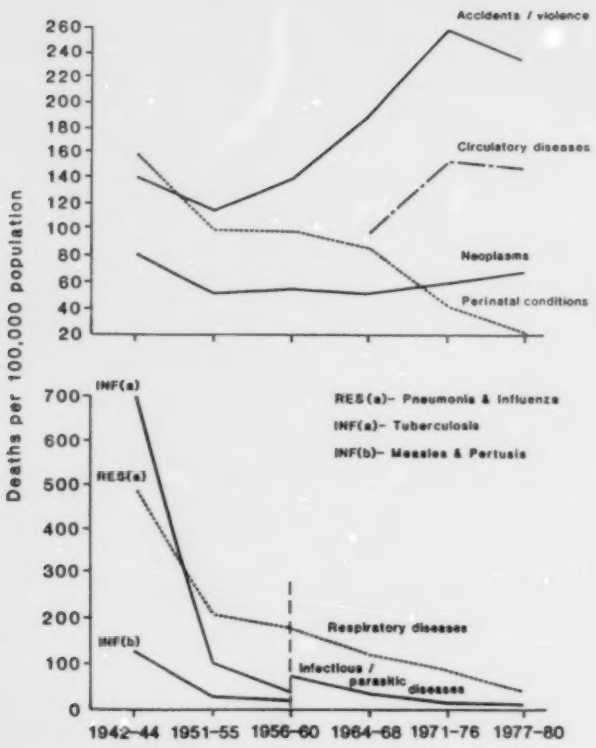


Figure 5.4 Historical Change in Canadian Indian Mortality by Cause

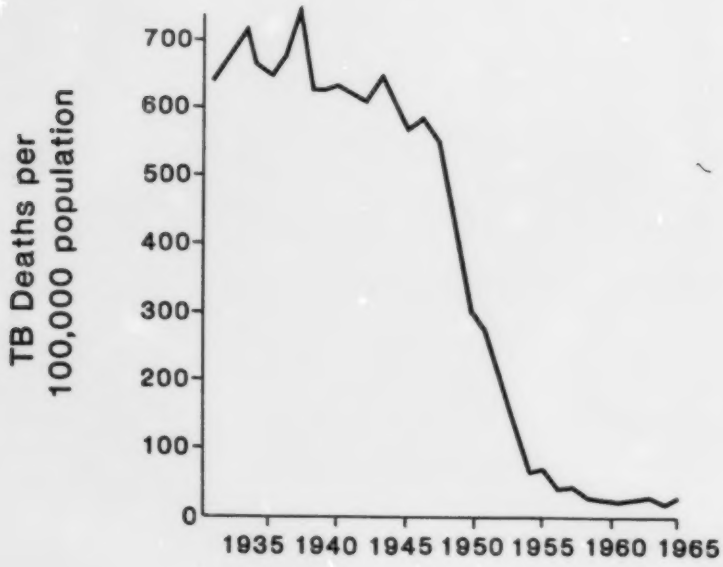


Figure 5.5 Decline in Tuberculosis Mortality among Canadian Indians

[Source: Reproduced from Young (1988)]

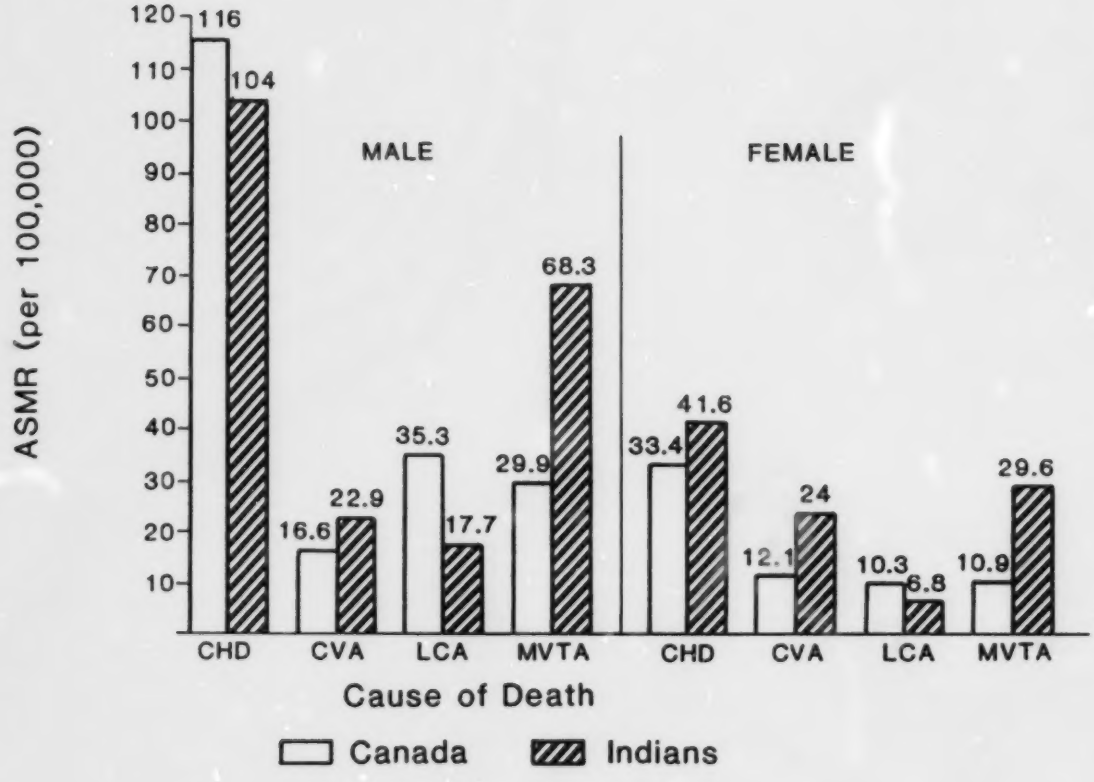


Figure 5.6 Age-Standardized Mortality Rate by Selected Causes: Canada and Canadian Indians, 1977-1982

[Source: Based on data from Mao et al (1986)]

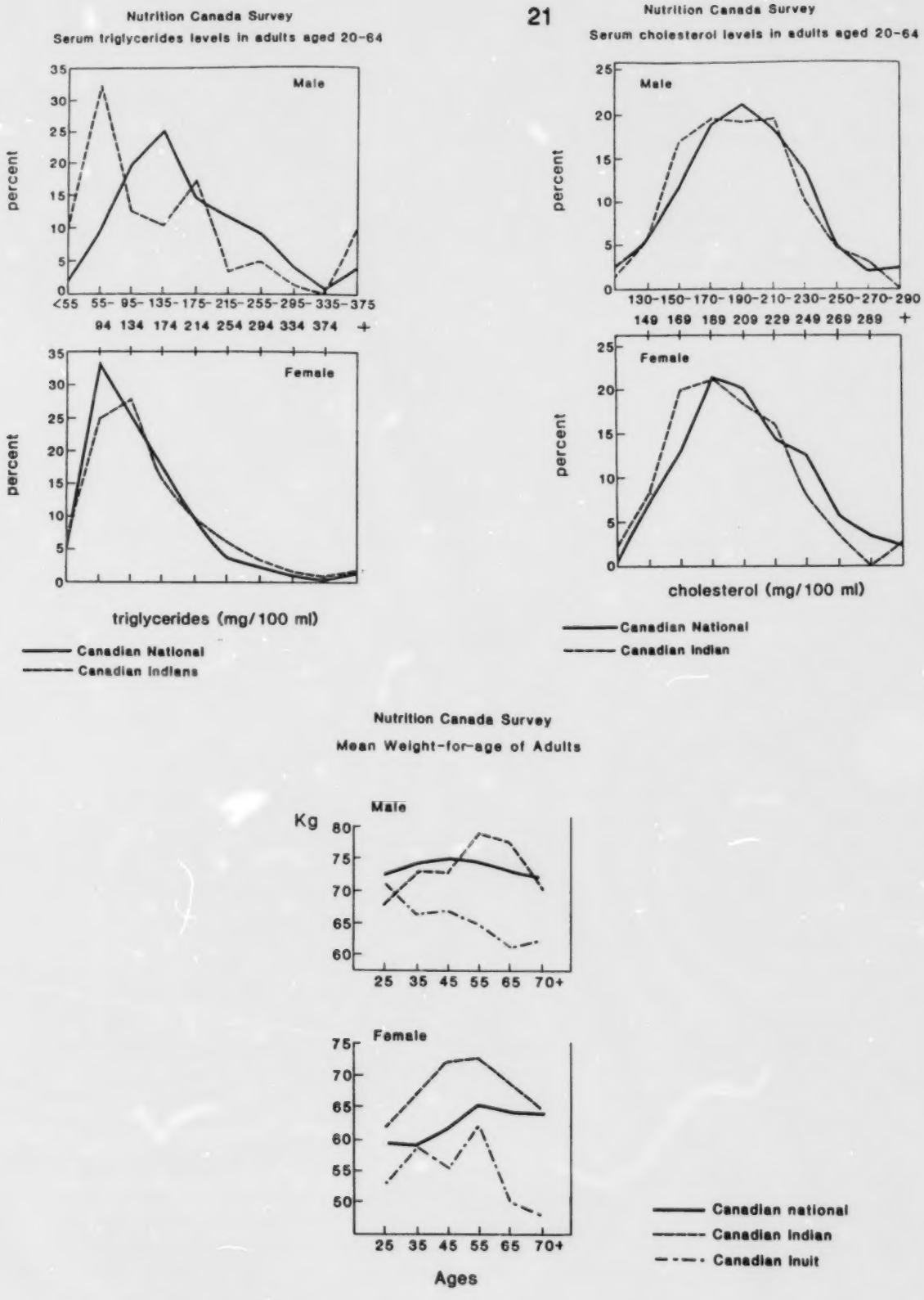


Figure 5.7 Selected Data from the Nutrition Canada Survey 1970-72

Manitoba. It is possible to compute standardized morbidity ratios for various categories of diseases, comparing status Indians with the total provincial population (Table 5.1).

In addition to the use of data derived from vital statistics, medical care utilization, and disease registries, the health status of a population can be assessed from community health surveys, which may include interviews, clinical examinations, and laboratory tests. In Canada, there have been several major national health surveys in the last two decades such as the Nutrition Canada Survey (1970-72), the Canada Health Survey (1978-79), the Canada Fitness Survey (1981), the Canadian Health and Disability Survey (1983-84), the Canada Health Promotion Survey (1985), the General Social Survey (1985), and the Health and Activity Limitation Survey (1986-87). Regrettably for logistical reasons, most of these surveys specifically excluded Indian Reserves and the northern Territories, with the exception of the Nutrition Canada Survey (NCS) and the Health and Activity Limitation Survey (HALS). Selected data on obesity and serum lipids for Canadian Indians from the NCS are presented in Fig.5.7. Data on Indian reserves from HALS have not yet been published.

6. Studies on Housing and Health in Native Communities

This chapter summarizes the results of an exhaustive search of all published and unpublished case studies (including dissertations, consultants' reports and government papers) dealing with housing, sanitation and health in Native communities in Canada. In addition, a few studies from U.S.A. Indian reservations and Greenland were also consulted and reported.

6.1 Canadian Indian Reserves

Pritchard and Fleisher (1977) reviewed existing data with respect to water quality and health statistics for the 41 communities affected by the Northlands Agreement in Manitoba. This is the only study which actually collected data on water quality by community (1975-76 coliform counts using the Most Probable Number method). Disease outcomes were measured by notifications of communicable diseases and hospital morbidity data from the Manitoba Health Services Commission. Although data on community infrastructure and health services were reported to be collected, no attempt was made to incorporate these factors in the analysis.

The authors were not able to observe an association between disease incidence and various ranges of coliform counts in the communities. Data were not sufficient to allow for an independent re-analysis. The authors also admitted to problems with sampling, particularly since water quality data were not consistently available for all communities or regularly throughout the year. There were also technical problems associated with sampling, transportation and analysis. Health data, particularly those from local nursing stations were also inadequate, inaccurate and incomplete.

In Saskatchewan, Dennis and Pearson (1978) correlated provincial health insurance plan hospital data with community profiles of central heating, running water and crowding. Indian hospital admission rates were higher than provincial average for most diagnoses, particularly pneumonia, burns, intestinal and skin infections. The 10 reserves with the highest proportion of homes with central heating had lower respiratory disease admission rates in the under-5 population than the other reserves. There was no significant difference in terms of intestinal and skin infections between the 10 reserves with the highest proportion of homes with piped water supply and the others. There was a correlation between population density (in 3 categories) and hospital rates

Table 5.1
Standardized Morbidity Ratios for Selected Causes, Registered Indians in Manitoba, 1981-82

ICD-9 Chapter	Diagnosis	SMR
I	Infectious/parasitic diseases	4.3
	intestinal infections	5.0
	tuberculosis	23.8
II	Neoplasms	0.7
III	Endocrine/metabolic/nutrional diseases	3.9
VI	Nervous system/sense organs	2.7
	meningitis	3.3
VII	Circulatory system	1.8
VIII	Respiratory system	3.0
	pneumonia/influenza	6.7
XV	Perinatal conditions	1.9
XVII	Injury/poisoning	3.3

Source: computed from Manitoba Health Services Commission data (cited in Young 1988:53)

of intestinal, skin, and middle ear infections, and burns in all age groups.

Ginsberg (1980) hypothesized that the factors which sustained underdevelopment in northern Manitoba also sustained poor health. In an ecological study of 18 northern communities (both Indian reserves and adjacent Metis settlements) she investigated the role of an array of "development" variables, including telecommunications, transportation, sanitation, community services, recreational facilities, organized activities, employment, and housing. Health status was measured using Manitoba Health Services Commission hospitalization and physician services data.

Overall the prediction that morbidity and development were correlated was only weakly supported. The presence of sewage systems was in fact significantly and positively associated with late childhood morbidity, and with morbidity from upper respiratory infections and gastrointestinal infections, contrary to expectation. Levels of organized activities were positively associated with adult morbidity and upper respiratory infections. It should be recognized that hospital utilization does not reflect only health status (or morbidity) but also other aspects such as severity of the condition, access to hospital and provider practice and referral patterns.

Duxbury (1983) determined the relative influence of environmental (housing, socioeconomic status, degree of community control, social disintegration) vs medical care factors (types and availability of personnel and facilities) on reported morbidity in 24 Indian communities in the Sioux Lookout Zone of northwestern Ontario. There were a total of 103 independent variables in the factor analysis. The logs maintained by nurses and community health workers, the first-contact primary care providers in these communities, served as the source of health data. These logs were developed as part of the evaluation of a telemedicine project and were standardized across all communities. From these the total number of patient visits, the total number of reported episodes of illness, the total number of reported episodes of respiratory illness and trauma were determined and used as dependent variables.

It was found that, compared to community and environmental factors, health service factors were relatively unimportant in predicting the level of morbidity in a community. Housing and sanitation, however, were not significant factors whereas socioeconomic variables were. One explanation offered by Duxbury was that there was too little variation in the quality of housing and sanitation among the communities, and thus their effect on reported illness was not apparent.

To examine the links between water supply and sanitation and health on Indian reserves, Brocklehurst (1985) selected 13 remote northern, western and southern reserves in Manitoba. Morbidity data pertaining to water-related diseases (intestinal and skin infections) were derived from a variety of sources: nursing station visits, communicable diseases notifications, and hospitalization and physician services from the Manitoba Health Services Commission. Water supply and sanitation data were obtained by household questionnaires and interviews. An average water consumption index and a servicing score related to water quality, convenience and system reliability were developed for each community. The servicing score was almost linearly related to water consumption, except at the upper and lower ends of the scale.

Plots of hospitalization rates by water consumption showed that rates for both enteric and skin diseases declined rapidly with increasing consumption, levelling off at a consumption level of about 90 lpcd, where hospital rates began to approach provincial averages. Plotting hospitalization rates with servicing score indicated that an overall score of 6.5 was necessary before levelling off of the curve occurred. [Scores under 6.5 included self haul of water and

delivery to small containers]. The authors recommended that system improvement should be implemented which make a daily consumption of at least 90 litres per person possible. The present system of trucked delivery to small containers should be discontinued.

Bruce (1991) modelled hospital utilization by Manitoba Indians in an ecological study which included a large number of housing, geographical isolation, demographic, socioeconomic, and health care variables. All 2-digit categories of diseases (ICD-9 chapters) were investigated in turn as outcome variables.

The results indicated that the percentage of households with sewage disposal was negatively associated with total hospital use, diseases of the respiratory and digestive systems. While this finding was unexpected, the lack of sewage disposal was highly correlated with accessibility by all-weather roads or rail and distance to the nearest hospital. Inadequacies in housing as measured by persons per room and proportion needing major repair had a significant effect on hospital morbidity. Access by all-weather road or rail was by far the most important factor and it was positively associated with hospital utilization for infectious and parasitic diseases, endocrine and metabolic diseases, diseases of the circulatory and genitourinary systems, musculoskeletal and skin disorders, as well with total hospital utilization for all causes. Distance to the nearest hospital was negatively associated with hospital use for mental disorders, injuries, and ill-defined conditions.

6.2 Northwest Territories

Michael (1984) studied the impact of water supply, sanitation and housing on health in the Northwest Territories. He did two studies, an ecologic one involving all communities in the NWT using official statistics, and a field study in three communities where more detailed information on individuals was obtained. No statistical analysis was performed other than tabular and graphical presentation of data.

Communities whose water supply was treated had lower rates of intestinal infections than those that practised disinfection only. The effect of water consumption was studied at the individual and household level. The relationship was similar to that described for Manitoba Indians in Brocklehurst (1985), with a levelling of the curve at around 60-70 lpcd for both intestinal and skin infections. There was also a linear (inverse) relationship between disease rate and water tank size, another measure of the quantity of water used. The rates of skin and intestinal infections were also higher among individuals served by a truck-and-honeybag system than those served by a truck-pumpout system in all three communities. In one community where a pipe/sewer system was in place, individuals served by the system had the lowest rate compared to the two other methods involving trucking.

For housing, rates of respiratory, skin and eye diseases were found to be higher in crowded houses (as measured by household size and number of persons per bedroom). No relation was found with housing type (detached, movable homes, etc) or tenure (government, private, rental).

Two studies looked specifically at infant health outcomes. The NWT Perinatal and Infant Mortality and Morbidity Study (PIMMS) followed a birth cohort of 1191 infants during 12 months in 1973/74 (Spady 1982). A large amount of data on socioeconomic status, health care, lifestyle, nutrition, obstetrical history, child care practices, and environmental quality (crowding and clean housing) were collected. The outcome include all significant health events (death, disease, and

developmental score) during the first year of life.

PIMMS is too complex to be summarized here. Those housing and sanitation factors which emerged as independent predictors of various health outcomes in multiple regression analyses are listed as follows:

Outcome Measure	Housing/Sanitation Factor
Infant mortality	bedrooms/home
No. morbidity visits	persons/bedroom
Morbidity score	persons/bedroom
Incidence of upper respiratory infections	persons/bedroom
Incidence of pneumonia	public water supply, household size, cleanliness of house
Incidence of diarrhoea	persons/bedroom, public water supply, household size
Skin infections	persons/bedroom, public water supply, cleanliness of house
Failure to thrive	public water supply, household size

A small case-control study involving 67 Inuit infant deaths from 9 communities during 1969-1971 and 67 survivor "controls" matched for age, sex and community was reported by Hobart (1975). A large number of predictor variables, very similar to those used later in PIMMS, were investigated. Three health outcomes were used: survival/death, a monthly weighted medicated morbidity index, and a morbidity/mortality index. The report did not mention multivariate statistical techniques. On univariate comparisons, housing and sanitation factors (crowding, heating, toilets, hygiene, household size) all showed some relationship with the health indices (Hobart 1975).

6.3 Greenland

Bjerregaard & Bjerregaard (1985) reviewed the Danish and other literature on housing conditions in Greenland. Based on historical sources they calculated that the average space per individual was under 2 sq.m. during the 19th century and about 12.6 sq.m. in the mid 1970s. They conducted an epidemiological study in Upernavik town in the west coast of Greenland over a 12-month period (1979-80) and analyzed over 2600 health care contacts by 836 residents. Three housing groups were categorized according to house size, space per person, heating and water supply; social class based on education, occupation and source of income was also determined. The results indicated that:

(1) Residents of Upernavik town, predominantly Native Greenlanders [Inuit and mixed Inuit-European], when compared with Aarhus, Denmark, had age-standardized contact ratios greater than unity for pregnancy, skin disorders and accidents, and less than unity for neoplasms, endocrine and cardiovascular diseases.

(2) Comparing Inuit with Danes living in Upernavik showed that the Inuit had higher outpatient and hospitalization rates, especially for skin and respiratory infections and accidents.

(3) Among the Inuit, the poorest housing group had the highest hospital admission and

contact rate for skin infections and accidents. Those at the lowest social class had the highest number of contacts/person for respiratory infections.

In an earlier study in the south of Greenland, Berg and Adler-Nissen (1976) studied 286 households with children and composed a housing index based on dwelling type, water, sewage, heating and kitchen facilities, as well as measured overcrowding separately during day and night time. The incidence of colds over the previous 12 months was correlated with the housing, day burden and night burden indices; otitis media with only the housing and day burden indices; whereas tonsillitis and gastrointestinal infections were little affected by any of the three indices.

6.4 United States Indian Reservations

Lefebvre (1968) examined the effects on physical health and social function of public housing provided for 18 Indian families (117 individuals) in a reservation in North Dakota. Residents of a new housing project were surveyed over two 5-month periods "before" and "after" the rehousing. Seven indices were constructed, covering health, family and law, school performance, crime and delinquency, church attendance, family relationships, and community activities. Health indicators used included frequencies of communicable diseases, home accidents, teachers' assessment of students' diet and health problems such as head lice, scabies and impetigo. While this study (a dissertation) consisted of a small sample size, used no statistical tests, had no "control" group (ie.a comparison group which was not rehoused), the author concluded that the level of physical health and social functioning improved after rehousing.

Rubenstein et al (1969) studied diarrhoeal diseases during infancy in a Hopi pueblo (population 700) from 1961-67. This community was divided politically and culturally into a "progressive" and a "traditional" faction. In 1964 the federal government installed indoor plumbing in the community but the traditionalists refused to accept it and continued to use outdoor taps and privies. The study revealed that the traditionalists had higher outpatient visits for diarrhoea and hospital admission for all causes and diarrhoea than the progressives. Among the latter, there was also a decline in all-cause and diarrhoea outpatient visits after the plumbing installation but no significant change could be observed among the traditionalists.

In an ecologic analysis of hospital utilization and surgical procedures on the Navajo reservation, Kunitz and others (1981) compared 8-year hospital use data in 18 land management districts. A large number of independent variables were included: socioeconomic, health care accessibility, and housing. The last mentioned group included percent living in a hogan, a traditional Navajo dwelling, percent with bathroom and household size. Distance of a community from the nearest hospital was the best predictor of total hospitalization rates, although wage employment and household size were also significant factors. Interestingly the proportion of dwellings with indoor bathrooms was a significant predictor of surgical rates (cholecystectomy, appendectomy and hysterectomy). The authors attributed this to the fact that the presence of indoor bathrooms was a proxy measure of modernization.

Engleberg et al (1982) analyzed outpatient visits for diarrhoeal disease at the San Carlos Apache Reservation in Arizona during 1977-79 and noted a sharp increase in cases late during October and November each year. During the 1980 diarrhoea season, a small case-control study was done involving 19 patients and 12 controls under two years of age. Over half of the cases were found to have diarrhoea due to rotavirus. Four household risk factors were investigated, and their relative risks were as follows:

(1) Presence of sibling under 2 years of age/absence = 13.4
(2) Presence of dogs/absence = 9.3
(3) Absence of indoor water service/presence = 6.1
(4) Absence of indoor toilet/presence = 8.1

Only (1) and (2) were statistically significant. Due to the small size of the study there was insufficient power to detect a significant difference involving factors (3) and (4) had there in fact been a difference.

A larger case-control study of rotavirus diarrhoea in the White Mountain Apache Reservation showed that exposure to other children with diarrhoea was the most important risk factor, although a high score for poor environmental sanitation was also significant. These factors were independent of mother's education, age and employment status (Menon et al 1990).

PART THREE REVIEW OF THE INTERNATIONAL LITERATURE

7. Housing Conditions and Crowding

7.1 Introduction

The health effects of poor housing have been recognized for a long time. Major advances in public health in the developed countries in the 19th century occurred when the dismal living conditions of the urban poor were ameliorated. Formal epidemiologic analyses of the association between health status and housing conditions began in the 1930s. Studies in that period used mortality rate as the outcome measure, particularly mortality from infectious diseases and respiratory conditions and mortality during infancy. The range of conditions studied changed over the years, as did the type of "exposure" variables. In recent years attention has been shifted from gross dilapidation and unsanitary conditions to problems associated with indoor air quality and other chemical and physical hazards that exist in the residential environment. In terms of health effects, attention has also changed from severe morbidity to psychosocial well-being.

An excellent bibliographic guide, particularly to some of the earlier literature, has been published by the World Health Organization (Martin et al 1976). Martin (1967) reviewed some of these studies, with an emphasis on those from the United Kingdom. The continuing interest in housing and health is evident from the recent series of short review articles in the British Medical Journal (Lowry 1989-90). While attention is usually focused on how housing affects health, the reverse relationship, that of the selective availability of housing according to health status, is also possible. This aspect has only recently begun to be analyzed (Smith 1990). In jurisdictions such as the United Kingdom, professionally-determined medical priority can be assigned in the allocation of public housing. Where housing is primarily in the private sector, the sick poor may be concentrated in certain housing areas and housing types.

The range of health problems which can be attributed to poor housing conditions is large, from psychological and physiological effects to specific diseases varying in the degree of associated morbidity. Richter (1973) listed the following environmental health and safety problems associated with housing (primarily from a U.S. inner city perspective) and measures for their control (Table 7.1).

In this chapter, studies demonstrating specific health effects are reviewed, followed by a discussion of the methodological issues inherent in such studies. Finally the extent and magnitude of such health problems on Canadian Indian reserves is assessed. Studies dealing specifically with water and sanitation, indoor air quality, and safety are reviewed separately in chapters 8, 9 and 10.

7.2 Physiological Effects

The quality of housing affects different physiological functions of the human body without necessarily resulting in specific diseases. Goromosov (1968) reviewed the international literature for WHO and examined the physiological basis for various existing housing standards. Physiological effects can be grouped into those relating to thermoregulation, indoor air circulation, illumination, and acoustic comfort.

The body reacts to temperature changes by altering skin temperature and humidity, pulse and

Table 7.1 Housing-Related Health Problems and Their Control

Health Problem	Control Measure
Respiratory infections	Boiler repair/maintenance, room humidification, window repair
Rodent and flea bites, vector-borne infections	pest control, garbage removal
Accidents, injuries, falls	hallway lighting, flooring, windows, railings on stairs
Burns from fires	installing fire extinguishers, fireproofing, retardants
Carbon monoxide poisoning	boiler repair/maintenance
Lead poisoning	wall covering, plumbing repair
Skin infections from insect bites	drainage of pools in yards, cellars
Asthma from mites, dust, rodent danders	pest control, scrubbing/mopping floors
Diarhheal diseases	plumbing repair/maintenance

Source: Richter (1973)

Note: personal hygiene, health education and training, medical care not included in list of control measures.

respiratory rate, and blood flow to the skin. A "comfort zone" for ambient temperature in the room can be established. It should be recognized that the indoor environment has a microclimate which is dependent upon the type of heating, ventilation, lighting, and number of occupants.

The types of airborne contaminants which can accumulate in indoor air are discussed in greater detail in Chapter 8. Standards exist for cubic capacity (cubic metre per person), the minimum fresh air supply (cubic metre per hour per person) and the frequency of air replacement (changes per hour). Apart from specific health effects from individual substances, the odour associated with a stale, poorly ventilated indoor atmosphere is also an annoyance and irritant.

Comfortable visual function depends on the adequacy of illumination. To avoid visual fatigue, standards exist governing the intensity of illumination in working areas within the field of vision, variation in brightness, contrast, glare and shadows. Windows must be available and properly oriented to allow in optimal natural sunlight (insolation).

Noise can be defined as unwanted sound. Unlike industrial noise, domestic noise is more of an irritant and generally poses little risk to hearing (Lowry 1989:1439-42). The large body of data on the physiological effects of noise on man have been reviewed in a National Research Council of Canada monograph (Thiessen 1976). It has been determined that 75 dB for 8 hrs/day can result in permanent hearing damage. Vacuuming can increase noise level from 50 dB to 80 dB but the exposure is usually short. What constitutes "noise" is personal and subjective, and does not depend only on the intensity of the sound, but also its unexpectedness, interference, inappropriateness, intermittency and reverberation (Farr 1967).

7.3 Specific Diseases

Diseases which have been associated with poor housing include the infectious diseases, non-infectious respiratory diseases such as asthma, chronic conditions and injuries. Table 7.2 summarizes the main findings of a selection of studies from around the world and from the 1940s to 1990. This is not an exhaustive list but is illustrative only of the range of methodology used and health effects studied. Only the more accessible English-language peer-reviewed journals have been searched. Note that some of these studies did not have housing as their primary focus. For the purpose of the table, only variables related to the housing environment were listed under "exposure" and discussed under "results".

The epidemiology of respiratory infections (including pneumonia, influenza and acute upper respiratory infections) was recently reviewed by Graham (1990). Many risk factors have been investigated: outdoor and indoor pollution, smoking, crowding, nutrition, psychosocial stress, climate, SES, etc. Crowding as a risk factor has been investigated dating back to the 1920s and 1930s (eg. Woods 1927) when mortality was frequently used as an outcome measure. More recent studies (eg. Leeder et al 1976, Monto et al 1977, Gardner et al 1984) showed that the number of sibs in the family was a predictor of respiratory morbidity. Collins et al (1971) reviewed respiratory mortality in England and Wales from 1958-64 and found that crowding was correlated with all-cause, bronchopneumonia and all respiratory disease mortality in the 0-1 year old whereas for the 1-4, 5-14, only accidents were correlated. Using partial correlation [a popular multivariate procedure in the days before multiple regression] they found that domestic and industrial pollution accounted for much of the variation.

Cold climate per se is probably not an important factor in "catching a cold", despite common

Table 7.2 Summary of Studies on Housing Conditions and Health

Author (Year)	Location/ Population	Exposure Variables	Health Outcomes	Type of Study	Control for Confounders	Results/Comments
Britten (1941)	USA total pop 1st National Health Survey	*crowding *toilets *rental value	*disabled>1wk/yr *child infect. *TB, enteric dis. *home accidents	XSS 2.5 million subjects	age, sex family income relief status	crowding related to total disability, TB, pneumonia, childhood infections; flush toilets - lower enteric dis. low rental value - high accident rate
Woolf & Waterhouse (1945)	England & Wales county boroughs	*crowding (% families living in >1 person/rm)	*infant mortality 1928-38	Ecol.study	soc.class, unemployment, latitude, women working in industry	gradation of IMR: unemployed+poor+ overcrowded > overcrowded+poor > all poverty indices zeros
Quinn et al (1948)	Connecticut urban and rural schools 11-15 y.o.	*crowding at home	*rheumatic heart disease by exam and history	XSS 3141 children	sex, race urban/rural	prev of rheumatic heart disease higher in crowded homes, regardless of rural/urban
Blum & Elkin (1949)	E.Tennessee, US Atomic Energy Commission reserve peak pop 75,000	*dwelling type *housing area	*epidemic cases meninigococcal meningitis	XSS	age,sex,race length of residence	univariate/bivariate analysis: incidence rate in "white standard" < "white slum" < "coloured" area
Gelperin (1950)	New Haven, CT 12,000+ children 5-13 y.o. from 37 schools	*5 categories of housing quality determined by appraisal method	*cases of URI *days absent from school	XSS	nil	"superior/good" areas had higher no. days absent/case and cases/1000 pupil-days than other categories; [confounded by SES - access to medical care;non-working mothers able to stay home etc]
Schmitt (1955)	Oahu, Hawaii 42 urban census tracts	percent of units *dilapidated *overcrowded	*all deaths *infant deaths *suicides *cases of TB, STD *admissions to mental hospitals	Ecol.study	nil	partial correlation analysis: dilapidation > overcrowding for TB, suicides, and mental disorders; overcrowding > dilapidation for STD, all deaths and infant deaths
McMillan (1957)	Glasgow, UK 37 city wards	*ave.no.rooms/house *ave.no.persons/rm *% pop in h.holds with 2+ persons/rm	*TB case rate	Ecol.study	age,sex history of TB contact,	ward TB incidence corr. with all 3 crowding indices
Wilner et al (1962)	Baltimore, MD black families urban slum	*8 measures of housing quality	*resp infections *skin,enteric dis. *mental health *accidents *crime statistics *school performance	Cohort study 300 families moved to new housing;300 did not		7 repeat exams in 3 years; rehousing associated with better health under age 35, esp. men under 20 y.o. General improvement in psychosocial indicators also noted
Stockwell (1963)	Hartford, CT and Providence, RI urban census tracts	*index" composed of 3 SES measures + rental value and overcrowding	*age-standardized mortality rate: all causes heart disease infectious dis.	Ecol.study	age, occup, income, educ	SES correlated with mortality: relationship varied between cities and SES index used (whether housing included or not)
Collins et al (1971)	England and Wales counties children	*domestic and industrial pollution *crowding *pop density	*child mortality 0-1,1-4,5-14 resp diseases accidents	Ecol.study	age, educ soc.class	domestic pollution and crowding correlated with all-cause and resp mortality in age group 0-1 and with accidents among 1-4 y.o. Partial corr:domestic and industrial

						pollution most important, other factors no longer significant
Ghipponi et al (1971)	Upper Volta: 2 urban districts & 2 villages; Mali: 2 urban districts	*type of house: floor/roof/windows *temp *RH	*bacterial counts in air sample	Ecol.study n=26 houses	nil	higher bacterial counts during dry season; houses with windows and cement floor had lower counts;
Wambem & Piland (1973)	California, small black, low-income community	*rehousing: various indices of crowding, amenities & structural flaws	*outpatient visits (housing-related & non-related)	Cohort study 18 mo before 12 mo after rehousing	2 groups said to be similar in SES demographics	reduction in housing-related outpatient visits in rehoused group
Booth & Cowell (1976)	Toronto, white families with children	*neighborhood crowding *household crowding indices from observation & interview	*symptoms *physical exam *blood and urine tests	XSS 560 h.holds 522 wives 334 husbands	age, sex, educ husband's occup, ethnicity	only small or nonsignificant effect on health status
Duvall & Booth (1978)	Toronto, white married women with children	*space/privacy *structural defects *noise, cold, pests	*mental health *physical exam *self-reported illnesses	XSS 560 h.holds 522 wives	age, sex, educ husband's occup, ethnicity	total no.MD-dx illnesses assoc. with minor structural defects; psychiatric impairment index assoc. with privacy, space problem index, major structural defects, and noise
Brennan and Lancashire (1978)	England and Wales counties	percent houses with *1+ persons/room *no hot water, bath, indoor toilet *owner occupied	*child mortality 0-4, 5-14 during 1971	Ecol.study	soc.class unemployment	partial corr.coeff. among age 0-4 density and amenities 0.2-0.3 owner occupied homes -0.2 among 5-14, effect of crowding NS after controlling for soc.class
Holma & Kjaer (1980)	Copenhagen, apts in older district	composite "housing standards" index: *crowding, cold, damp *heating, vent.	*symptoms by IAQ	XSS n = 881	alcohol, smoking	housing standards associated with symptoms
Melia et al (1982)	N.England, urban public housing 5-6 y.o.in 4 schools	*NO2 *temp *relative humidity thermohydrograph air sampling	*resp symtpoms by SAQ to mothers	XSS 183 homes 191 children	age, sex, soc.class, no.smokers in home	prev of resp symptoms not associated with weekly NO2 levels in BR or LR
Aaby et al (1984)	Guinea-Bissau, urban	*crowding *house size *flooring (cement vs earth)	*measles cases *case fatality *age at onset	case series	nutritional status, parental educ	overcrowding increased risk of early infections and case-fatality
McCarthy et al (1985)	N.England, urban public housing adults	*housing area *dwelling type by observation	*resp symptoms scale by IAQ	XSS 533 adults	age, smoking, soc.class, unhealthy workplace	resp symptom scores higher in "bad" housing area ("difficult to let"); worse in older houses; high rise worse than low/medium rise apts
Elton & Packer (1986)	Salford, UK applicants for rehousing on grounds of mental ill-health	*rehousing [current environment too noisy, violent, dirty, dilapidated]	*mental health Q	RCT 28 pairs	nil	applicants randomly allocated to "priority" and "non-priority": significant improvement in anxiety, depression and total scores
Martin et al (1987)	Edinburgh, UK public housing depressed area	*dampness self-asessed and by protometer	*symptoms by IAQ	XSS	smoking no.children	dampness associated with prev resp symptoms; crowding also a significant factor on loglinear analysis

Gabe & William (1987)	W.London, women 25-45 y.o. UK-born	*crowding	*GHQ -psychosocial symptoms	XSS 452 women	employment, soc.class	crowding has an independent effect on GHQ scores;J-shaped dose-response 1-1.5 persons/rm lower than both <1 and >1.5 persons/rm
Stuart et al (1988)	Gloucester & Plymouth health districts, UK	*crowding *damp,heating,vent.	*cases of meningo-coccal meningitis	CSS 2 controls - same district/ neighbourhood	matching for age,sex	dampness, public housing & lacking central heating risk factors; cases had smaller h.holds but no difference in no.persons/house or room
Victoria et al (1988)	S.Brazil, urban infants (excld.LBW/cong. malform./neonatal morbidity)	*water supply *water source *latrine type *crowding *house type IAQ + direct observation	*diarrheal diseases deaths	CCS 170 cases 340 alive neighbourhood controls	age, soc.class, infant feeding	RR: not piped/piped water = 4.8 shack/well-built house = 1.9 other factors (crowding, toilet type, treated water source) NS
Coetzee et al (1988)	S.Africa: village health project near Cape Town; pop 5,000	*crowding (3 indices) *age of dwelling	*TB cases	CCS 40 cases, 84 controls	age-sex matched	RR=4.8 dwellings >80yrs old crowding indices not associated with TB
Platt et al (1989)	Glasgow, London Edinburgh, public housing areas h.holds with children	*damp, moulds *structural *crowding observation + air sampling for spores	*general health Q *resp symptoms	XSS 1159 children in 597 h.holds	income, smoking, unemployment	prev of resp symptoms (wheeze,coryza, sorethroat), headaches, fever higher in damp house than non-damp; dose-response relationship observed: more symptoms associated with higher degree of dampness
Strachan (1988) Strachan & Sanders (1989)	Edinburgh, UK 3 schools 7 y.o.	*heating, vent. *dampness, moulds SAQ to parents; moisture by elect.conductance; temp/RH by thermo-hydrograph	*resp symptoms SAQ to parents *physical exam *ventilatory function test	XSS 1000 SAQ 940 exams 778 moisture tests 317 thermo-hydrograph monitoring	smoking crowding gas cooking tenure	prev resp symptoms higher in self-reported damp houses; RH/temp monitoring not associated with symptoms; FEV1 not associated with dampness RR mouldy house = 3.0 for wheeze and 2.1 for colds (adjusted)
McGlashan (1989)	Tasmania, Australia	*housing area *denisty *ventilation *other non-housing factors (main focus of study)	*Sudden Infant Death Syndrome cases	CCS pop. based 2 controls born before/ after SIDS case in same hospital	nil; univariate comparisons	RR=2.6, public housing RR=0.4, window/door open density and heating worse in cases compared to controls
Hyndman (1990)	London, UK East-End public housing, Bengali immigrants	*house type,tenure *heating, vent. *cooking facilities *damp,cold,moulds *crowding IAQ, thermohydro-graph, air sampler for spores	*self-reported general health *resp conditions *lung function IAQ, peak flow meter	XSS 60 h.holds 345 people	age,sex, soc.class, smoking, occup	Compared centrally heated with non-centrally heated homes, (all other housing and SES variables similar): correlation between reported dampness and reported lung health; correlation not found using objective measures
Barker et al (1990)	England and Wales local authority areas	*domestic crowding in 1971,1951,1936 and 1931 *SES	*stomach cancer mortality 1968-78 death certificates	Ecol.study	age, sex	SMR for ages 35-74 correlated with both SES and domestic crowding. Corr.coeff.between SMR and crowding in 1971=0.46, in 1951=0.53, 1936=0.64 and 1931=0.60. Concluded that crowding in childhood is risk factor perhaps reflecting poor food storage

Notes:

apt = apartment
BR = bedroom
CCS = case-control study
dis. = disease
Ecol. = ecological study
educ = education
GHQ = General Health Questionnaire
h.holds = households
IAQ = interviewer-administered questionnaire
LR = living room
NS = not statistically significant
occup = occupation
pop = population
prev = prevalence
RH = relative humidity
RR = relative risk
resp = respiratory
rm = room
SAQ = self-administered questionnaire
SES = socioeconomic status
SMR = standardized mortality ratio
STD = sexually transmitted diseases
temp = temperature
TB = tuberculosis
URI = upper respiratory infections
vent. = ventilation
XSS = cross-sectional survey
y.o. = years old

belief. Experimental studies on cold, damp volunteers infected with rhinoviruses have not been able to show significant adverse effects (Douglas et al 1968). Recent studies on damp housing in Europe, based on both subjective report and objective measures (eg. using a thermohydrograph), found correlation with various respiratory symptoms such as cough, wheezing, and shortness of breath (eg. Holma & Kjaer 1980, Martin et al 1987, Strachan & Sanders 1989).

Other infectious diseases commonly associated with crowding include tuberculosis (Britten 1941, Schmitt 1955, McMillan 1957, Coetzee et al 1988), meningitis (Blum & Elkin 1949, Ghipponi et al 1971, Stuart et al 1988)and measles (Aaby et al 1984). Among non-communicable diseases which have been shown to be related to housing is rheumatic heart disease (Quinn et al 1948), which in fact is the sequela of streptococcal infection. Of particular interest is Barker's (1990) study of stomach cancer, which was found to be related to earlier exposure to crowding during childhood. The authors attributed this to poor food storage, which leads to contamination with microorganisms and the production of toxic/carcinogenic substances.

Pests, whether rodents or arthropods, are scorned because of their potential role as disease vectors. Diseases which could be transmitted by rodents include plague, tularemia, lassa fever, rabies, various hemorrhagic fevers, and scrub typhus (WHO 1974). However, few of these are of public health importance in North America. The presence of rodents is more of a nuisance, although they could damage sewerage systems and ruin food storage. In urban slums, there have been reports of rodents biting infants.

Among the arthropods, cockroaches are universally loathed but are associated with few specific diseases. At one time they were suspected vectors for infectious hepatitis, although the evidence was only indirect. Tarshis (1962) reported that in one housing project in Long Beach, CA previously known to be hyperendemic for hepatitis A, the incidence of the disease drastically declined in 2 years concurrent with a cockroach control program which reduced infestation by 70%, whereas elsewhere in Los Angeles County the disease was on the rise.

Scabies is caused by the burrowing of a mite in the skin. Among risk factors associated with its transmission are SES, personal hygiene and overcrowding, although the evidence is not consistent (Green 1989). As intrafamily spread is well recognized (Church et al 1978), it is to be expected that increased family size should be a risk factor (Sharma 1984), although other behavioral factors may be more important such as sleeping pattern and the sharing of towels and clothes (Gulati et al 1977, Blumenthal 1976).

7.4 Mental Health and Psychosocial Effects

Studies on the effects of space, spatial arrangement, furniture design, aesthetics etc on human behaviour and performance in the psychological literature have been reviewed by Griffin et al (1969). Privacy and circulation within the dwelling are deemed to be important factors for psychological well-being (Chapin 1951). Loring (1966) reviewed the sociological literature on the effect of the physical aspect of the residential environment on social interaction and individual well-being.

Crowding is now more a threat to mental than physical health, although in Hong Kong, one of the most crowded cities in the world, little ill effects in terms of family relationships, mental health, and work performance could be demonstrated after controlling for poverty (Mitchell 1971). Sociologists

make the distinction between density - the number of people per unit space, and congestion, which reflects the simultaneous demands for the use of available space. The adverse mental health effect of crowding stems from the lack of personal control over the available space, rather than the actual small size of the space (Mitchell 1976). Cultural variations in definitions of "crowding" also play a mediating role.

The long dark winter common to all circumpolar countries is now recognized as contributing to the psychiatric syndrome known as seasonal affective disorder (with the appropriate acronym SAD). Indoor lighting is believed to play an important therapeutic role (Rosenthal et al 1985). A large body of research on SAD is now emerging from Soviet and Alaskan scientists, as evident from the number of papers presented at the May, 1990 International Congress on Circumpolar Health in Whitehorse, Yukon.

For many women, the home is both an occupational and residential environment. Few studies have in fact been devoted exclusively to women's health and housing. Duvall and Booth (1978) reported on the relationship between housing and various indices of women's physical and mental health within a larger survey in Toronto. Gabe and William (1987) in West London demonstrated an independent effect of crowding and mental health as measured by the General Health Questionnaire. Interestingly both the "undercrowded" (<1 person/room) and "overcrowded (>1.5 person/room) were worse off than those occupying dwellings with between 1 and 1.5 person/room.

7.5 Methodological Issues

In reviewing Table 7.2, several study designs can be observed. Ecologic studies refer to those studies where the units of observation and analysis consist of aggregates of individuals rather than individuals themselves. Such aggregates include census tracts (Schmitt 1955), county boroughs (Woolf & Waterhouse 1945, Collins et al 1971, Brennan & Lancashire 1978, Barker et al 1990) and city wards (McMillan 1957). For example, in the study by Schmitt (1955), the comparison was between census tracts with a high proportion of houses dilapidated or overcrowded and those with a low proportion, rather than a comparison between individuals living in dilapidated or overcrowded houses and those not living in such houses. It is possible that not all people living in "poor-housing" census tracts do in fact live in poor houses and exposed to the associated deleterious effects. A correlation based on group characteristics is not necessarily reproduced at the individual level - it may disappear or even be reversed. An incorrect inference due to the inability to distinguish the different levels of observation and analysis is termed "ecologic fallacy". On the other hand, ecologic studies are particularly suited for studies on housing and health since aggregate data may be more readily accessible and available than mounting a survey involving interviewing and measuring individuals. The issue of sample size is also critical: even though the actual population may be quite large, the number of aggregate units may be very small. An extreme example would be a comparison of two cities - no matter how large they are, the effective sample size is only two.

Another study design, which is by far the most commonly used, is the cross-sectional survey [XSS], which is characterized by the concurrent measurement of both exposure and outcome variables. The typical study involves interviewing a sample of residents, who are questioned regarding health problems as well as their current housing situation. The major disadvantage of XSS is that, if one is interested in causal inference, a major criterion - that of temporal sequence - is not met. If poor health actually precedes poor housing, it cannot then be "caused" by the poor

housing. Bias can be introduced if people with poor health are moved into better housing for therapeutic reasons, with the result that the benefit of good housing is underestimated. The advantage of XSS, on the other hand, is that it can be done relatively quickly.

Less commonly used are case-control studies [CCS](Stuart et al 1988, Victoria et al 1988, Coetzee et al 1988). In a CCS, people with the outcome, called "cases" are first identified (eg. tuberculosis cases); another group who do not have the outcome, called "controls", is also selected. These two groups are then compared in terms of their odds of being exposed to the suspected risk factor (eg. overcrowding). Because the direction of inquiry is from "outcome" backwards to "exposure", temporal sequence also cannot be firmly established. CCS, however, are particularly suited for studying rare outcomes, since in a XSS it would take a very large sample to generate enough cases.

Rarely conducted in housing and health studies are cohort studies, which follow forward in time from exposure to outcome. While strongest in terms of ensuring temporal sequence, they are generally expensive to conduct and require long period of follow-up and/or large number of subjects in order to detect any effect. One of the few cohort studies in housing is the Johns Hopkins Longitudinal Study of Housing on Health and Social Adjustment, started in 1954 and involved some 300 Black families about to be rehoused and another group who remained in the slum (Wilner et al 1962). Note that a cohort study is observational rather than experimental, since the "exposure" is decided by the subjects, not allocated by the investigator.

Considered the most rigorous design in ascertaining cause-and-effect, the randomised controlled trial [RCT] is particularly useful in the evaluation of interventions. It requires randomly allocating individuals or families to deliberate exposure to poor (or good) housing, or some of its components, and observe the effect prospectively. Such a feat of social engineering would ordinarily not be acceptable ethically. Only one RCT involving housing has been reported. Elton and Packer (1986) studied the result of rehousing people who applied for medical priority for rehousing on the grounds of mental symptoms in Salford, U.K. The justification for the use of a RCT was that because of the large demand for rehousing the probability of being given medical priority for mental symptoms was believed to be less than 50%. Thus by participating in the study, those randomly allocated to rehousing would gain while those not so allocated would not have lost anything. Also participation in the study would not disqualify any one from being rehoused on other grounds. What is also remarkable about the study was that informed consent was not obtained from the participants - the investigators believed that most would refuse - only the approval of municipal politicians was sought! While the ethics of the study may have been dubious, it did demonstrate, through the use of "before" and "after" testing with psychiatric symptoms questionnaires, that rehousing improved the applicants' mental health.

Many methodological biases can occur which affect the validity of a study. These can be classified into selection bias, information bias and confounding bias. An example of selection bias is non-representative sampling of communities within a region, such that only communities with available data or those which are geographically most accessible are studied. Non-response in a survey may preferentially exclude those who have the worst housing or worst health. Loss to follow-up in a cohort study or RCT may also exclude a particular group of subjects.

Information bias occurs when existing instruments (such as a survey questionnaire or air sampling device) are faulty or inadequate or they wrongly classify individuals/communities according to risk factor exposure or health outcome. In terms of exposure variables, most studies suffer from the fact that only current dwelling characteristics are measured, which do not reflect true lifetime

exposure, which is logically what "causes" poor health. Overcrowding is an appealing concept, yet there are many ways of "operationalizing" it. It can be measured as the number of people per room (which could be sleeping room only or any habitable room), the floor area per person, or the cubic volume of space per person. There is also the distinction between household crowding and neighbourhood crowding. Bias can also be introduced by a survey interviewer, whose knowledge of the health status of the respondent may affect his assessment of housing quality. Such a bias can be reduced by having separate teams collecting exposure and outcome information (ie."blinded"). Respondents may exaggerate their complaints regarding their inadequate housing and their health problems. Discrepancy between perceived defects such as dampness and those objectively measured using technical instruments has been encountered (eg. Hyndman 1990). CCS and XSS, which often depend on respondent's memory of events (whether relating to exposure or outcome) some time in the past, are vulnerable to recall bias.

In terms of health outcomes, early studies were able to use mortality (eg. infant mortality, mortality from infectious diseases, pneumonia etc) as the measure of health status. With the substantial advances in both housing conditions and mortality reduction over the past several decades, gross differences in such outcome measures can no longer be observed. [Although as late as 1971 in England and Wales childhood mortality differential by housing density was still demonstrable (Brennan and Lancashire 1978)]. Morbidity can be measured by official case notifications (which apply only to certain infectious diseases), hospital admissions, visits to physicians' offices and outpatient clinics, school absenteeism records, or self-reports in a survey setting. An early example of the use of self-reported morbidity is Britten's analysis of the first US National Health Survey of 1935-36 (Britten 1941). The choice of outcome measures often determine whether an effect can be detected. Measures of psychosocial well-being and mental health are particularly vulnerable.

Housing conditions rarely occur independently of other factors, particularly socioeconomic status, which is well known to be associated with adverse health effects. SES is thus a confounder in that it is associated with both housing and with health, and that one may incorrectly attribute poor health to poor housing when in fact it is low SES that is the real risk factor. Earlier studies generally had poor control for confounding, whereas more recent ones usually utilize one or more methods such as restriction, matching, stratification and multivariate statistical modelling. While scientifically it may be important to determine which is a "true, independent risk factor", from a policy perspective it may not be necessary to separate these factors. They are probably not separable in real life and housing improvements should be concurrent with other social and economic strategies. Another important confounder is smoking, particularly in studies which attribute respiratory symptoms or illnesses to poor housing conditions such as dampness.

7.6 Extent of the Problem among Native Canadians

The current status of housing and community infrastructure on Canadian Indian reserves has been summarized in Chapter 4. Indian reserves also suffer an excessive burden of many of the diseases associated with poor housing and sanitation discussed earlier in this chapter. Data relating to infectious disease mortality and morbidity among Canadian Indians are summarized in Table 7.3

In terms of the proportion of all deaths among Indians and Inuit, infectious diseases as a whole in the 1980s were not very important, compared to accidents/violence and cardiovascular diseases, which were the major killers. However, when expressed as risk of disease or death

Table 7.3 Risk of Mortality/Morbidity from Infectious Diseases among Native Canadians

ICD-9 Code	Disease	Author (Year)	Population/ Location	Relative Risk (Native/non-Native)
001-139	All Infectious/ Parasitic Dis.	HWC-MSB (1988)	Canada: MSB service pop.	mortality (unadj): 1978-81 = 6.0 1982-85 = 4.0
		Mao et al (1986)	IR, 7 prov. under 70 y.o.	SMR, 1977-82: M = 2.9, F = 4.4
		Young (1983)	NW Ontario Cree-Ojibwa	SMR, 1972-81: both sexes = 4.5
		Robinson (1988)	James Bay Cree, Quebec	Stand.hosp.ratio, 1980/81:M 1.7, F 1.6
		Evers (1982)	SW Ontario clinic users infants	RR hospitalization: = 3.1
010-018	Tuberculosis	Young (1983)	NW Ontario Cree-Ojibwa	SMR, 1972-81: both sexes = 7.7
		Enarson & Grzybowski (1986)	Canada	incidence (unadj): 1970-81= 15.6
		Young & Casson (1988)	NW Ontario Cree-Ojibwa	SIR, both sexes: 1975-79 = 15 1980-85 = 9
001-009	Intestinal infections	Young (1983)	NW Ontario Cree-Ojibwa	SMR, 1972-81: both sexes = 9.5
		Evers (1982)	SW Ontario clinic users infants	RR hospitalization: 24.3
480-487	Pneumonia & influenza	Mao et al (1986)	IR, 7 prov. under 70 y.o.	SMR, 1977-82: M = 2.9, F = 3.5
		Young (1983)	NW Ontario Cree-Ojibwa	SMR, 1972-81: both sexes = 6.5
		Evers (1982)	SW Ontario clinic users infants	RR hospitalization: upper tract = 7.4 lower tract = 5.8
320-326	Meningitis	Young (1983)	NW Ontario Cree-Ojibwa	SMR, 1972-81: both sexes = 12.1
		Wotton et al (1981)	Keewatin, NWT, Inuit	incidence (unadj) both sexes = 10.6

Notes: SMR = standardized mortality ratio
SIR = standardized incidence ratio
unadj. = unadjusted for age/sex (simple ratio)

relative to Canadians in general, the Native rate is several-fold higher (Table 7.3).

Rheumatic fever, known to be associated with overcrowding, has declined among Manitoba Indian children in the 1970s although the incidence rate is still higher than non-Natives (Longstaffe et al 1982).

7.7 Housing for Special Needs Groups

Two groups in any society - the aged and the disabled - have unique housing needs. There is, in fact, much overlap between these two groups, and the housing needs of the aged are usually not simply the result of aging but determined more by their deteriorating physical, mental and social functioning (Lowry 1990:321-3).

The elderly are particularly vulnerable to low temperatures: their thermoregulation is impaired, and their reduced mobility generates less heat. Another problem is the increased incidence of falls (Shapiro 1988). The risk factors for falls in the home include the following: pathophysiologic disorders affecting the visual, vestibular, proprioceptive, central processing and perfusion functions of the body; certain drugs and alcohol, and home factors - foot-ground contact (uneven, slippery floors, loose rugs), poor lighting, fixtures and furniture (eg. bathtubs, sharp edges), unsafe stairs, cluttered traffic lanes (Gibson 1987).

Canadian Indians, compared to the national population, are still relatively "young", with a much lower proportion of the population aged 65 and above (3% in the 1986 Census, compared to 10% among all Canadians). The Native senior has been largely overlooked in policies and programs in Canada which typically apply tc Natives in general, or the elderly in general. Up until recently, housing needs of the aged have not been a problem (ie. not more of a problem than that faced by Indians in general). There is a tradition of caring for the aged and infirm within the community and the network of the extended family. This tradition is increasingly under threat as Indian communities undergo rapid social and cultural change. Many elders forgo seeking medical or other assistance that they need in order to avoid being forced to leave their family and community. Those that do enter nursing homes outside of the Native communities frequently feel extremely unhappy and alienated. There is a need to provide alternatives for those seniors who require care that the family alone is unable to provide, without requiring them to leave their communities and destroying the satisfactory aspects of the social network (Shortt 1984).

The Health and Activity Limitation Survey, conducted by Statistics Canada during 1986-87, is one of the few national health surveys which included Indian reserves and the northern territories in its sampling (the other being the Nutrition Canada Survey of 1972). It has not yet released data relating to Indian reserves although a volume on the Northwest Territories has been published (Statistics Canada 1989).

The housing situation for the disabled on reserves is grim. Most lack supportive services such as home care. Special wheel chair access is rarely available for homes and public buildings. The poor conditions of many homes are not conducive to the maintenance of proper personal hygiene for the house-bound or bedridden.

8. Water Supply and Sanitation

8.1 Introduction

There is a large international literature on water supply and sanitation. Several monographs published by WHO and the World Bank (WHO 1980, Feachem et al 1981) have listed and summarized some of these studies, many of which are from developing, tropical countries, although there are also a few from the rural American South, migrant camps and Indian reservations. Table 8.1 summarizes the major findings from several of these studies.

Studies evaluating the impact of improving water supply and sanitation have taken two basic approaches: (1) cross-sectional, comparing communities with different sanitation facilities, and (2) longitudinal, comparing "before" and "after" the installation of particular systems, with or without control (ie. non-intervention) communities. Such designs are deceptively simple, but they in fact are beset with formidable methodological difficulties such as confounding with SES and cultural factors, and isolating the effects of water and sewage disposal from each other and from housing conditions and personal hygiene.

The indicators used are usually incidence rates of diarrhoeal diseases and prevalence of fecal parasites or positive bacterial cultures. Less often used are incidence rates of viral hepatitis, skin infections, eye infections, nutritional status, overall mortality and hospitalization rates.

8.2 Water and Sanitation-Associated Diseases

Many diseases are associated with environmental sanitation. A common practice is to classify them biologically into viral, bacterial, protozoal and helminthic. From the standpoint of control measures, such scheme is not very useful. Feachem et al (1981) devised an environmental classification of excreta-related infections (Table 8.2), while Table 8.3, based on several sources, presents a scheme for water-related diseases. There is considerable overlap between these two systems.

It is evident from these two tables that, despite the long list of possible diseases related to water and sanitation, few are in fact of any public health importance in North America, even on Indian reserves. While epidemics of diarrhoeal diseases still occur, particularly of viral gastroenteritis (Robinson and Moffatt 1985), overall such diseases contribute to only a very small proportion of mortality and morbidity on Canadian Indian reserves today.

8.3 Methodological Issues

While there is a large international literature on the impact of water and sanitation on health, many studies suffer from serious methodological flaws (Blum and Feachem 1983, Esrey and Habicht 1986). Some of these problems are common to all epidemiologic investigations, and have been discussed earlier under Housing Conditions in Chapter 7. Blum and Feachem (1983) discussed eight types of problems found in the 44 published studies they reviewed. Their prevalence raises serious doubts about the validity of the conclusions of many of the studies reported:

Table 8.1 Summary of Studies on the Health Effects of Water Supply and Sanitation

Author (Year)	Location/ Population	Exposure Variables	Health Outcomes	Type of Study	Control for Confounders	Results/Comments
Watt et al (1953)	California farm migrant workers	housing types water supply	prev Shigella	XSS	SES	low SES/outdoor water > low SES/ indoor water > medium SES/indoor water
Eyles et al (1953)	Tennessee, rural (90% black)	fecal pollution indoor toilet/privy water supply house cleanliness personal hygiene family size	prev Giardia, E.histolytica	XSS	nil	
Hollister et al (1955)	California farm labour camps children < 10 yrs pop. >6000	indoor vs communal: taps/showers/ toilets	prev. positive stool culture for Shigella	XSS	crowding	prev (+) cultures highest among cabins with no facilites > communal toilets/showers + indoor taps > indoor taps/showers/toilets; when matched for crowding, outdoor water taps > indoor water taps
Stewart et al (1955)	SW Georgia children	4 dwelling types: water/sewage/flies housing quality	incidence:"family-cu[illegible]nths"	Cohort study 28000 swabs	nil	among "poor" dwellings, infection rate higher when water quantity low and far from house;excreta disposal independent role unclear
Mackie et al (1956)	N.Carolina urban school children both races	water and sewage: indoor/outdoor, private/shared	excretion rate of E.histolytica	XSS n > 1000	nil	highest rate pit latrine > share flush toilet in yard > shared inside flush toilet > private inside flush toilet; yard tap > private water
McCabe & Hains (1957)	Georgia, rural children < 10 yrs	improvement of bore-hole privies	prev. Shigella stool culture; fly population counts	intervention control towns	nil	decrease in stool culture (+) rate after 18 months; no change in "control" towns; no change in fly pop.
Schliess-man et al (1958)	E. Kentucky, 11 mining camps pop.4000	inside vs outside water; privy vs flush toilet	rectal swab/stool culture for para-sites;fly counts; water quality; cases of diarrhea	Cohort study n = 4000	family size persons/room education (stratified analysis)	Shigella and Ascaris prev. and diarrhea incidence: off-premise, outside water + privy > on-premise, outside water + privy > inside water + outside privy > inside water + flush toilet
Brooke et al (1963)	Little Rock, AK general pop.	water: piped indoor vs wells; pit privies vs indoor flush toilet	prev. ameba (E.histolytica,coli hartmanni,nana)	XSS Ecol. study	age	well water higher rate > piped indoor among under-5s; little diff. when all ages combined; 4 areas: prev. rate correlated with % families with indoor flush
Gordon et al (1964)	Guatemala, rural highland, children	latrine vs nil	diarrhea incidence	XSS n > 3000	age	no latrine group had higher rate only among 1-5 y.o.; no sig. diff. under 1 or over 5.
Moore et al (1966)	Costa Rica, 120 houses in one canton	piped water	rectal swab/stool culture for para-sites;fly counts; water quality	XSS	nil	piped water important in reducing infections with enteropathic bacteria but not in diarrheal dis. incidence or parasite infestation

Goodwin et al (1966)	Arizona, 41 low SES families with piped water/indoor plumbing/refrig.	crowding personal hygiene	stool culture	XSS	nil	prev affected by behavioural characateristics, not crowding
Villarejos (1966)	Costa Rica	toilet: flush/ outdoor/nil water:surface/well/ communal	hepatitis case rate	XSS	nil	flush toilet houses lowest rate; well water lowest rate.
Van Zijl (1966)	7 countries in Asia, Africa, and S.America children	toilet:nil/outdoor/ indoor water supply	diarrhea incidence and Shigella isolation	Ecol. study	nil	areas without water supply > with; piped water without sanitation - rates still high
Kourany & Vasquez (1969)	Panama City, infants	6 dwelling types crowding, water sewage disposal SES	prev. Salmonella, E.coli, Shigella	case series 1819 clinic patients	nil	prev. declined as housing type improves
Sommer & Woodward (1972)	Bangladesh, rural children	distance from tubewells	cholera epidemic surveillance by daily rectal swabs	Cohort study n = 110	age, sex	during 1st epidemic (classical/Inaba) those living close to wells 4% culture positive vs 25% in those living far from wells; no difference during second epidemic (el Tor/Ogawa)
Azurin & Alvero (1974)	Philippines Bacolod City, 4 urban districts (pop 3089)	4 types: good/poor water: municipal piped = good sewage: water sealed toilets = good	incidence rate of cholera	Cohort study followed for 4 years	age	68% reduction in rate if only sewage "good"; 73% reduction if only water supply "good"; 76% reduction if both water and sewage "good"
Koopman (1978)	Cali, Colombia poor urban area school children	classroom crowding school toilet hygiene (scale based on water flow, toilet paper, soap/towels)	symptoms: diarrhea/ vomiting/colds/ head lice in 4 weeks	XSS 8219 students	sex	significant association of diarrhea/ vomiting symptoms with toilet hygiene headlice and colds associated with crowding indicators
Thacker et al (1980)	Haiti, urban children	water quantity (different effects of acute water shortage)	IAQ reports of child morbidity	Cohort study 2 urban areas n = 400 each	nil	disease rate associated with water availability (also affected by SES, family size in univariate analyses): diarrhea, scabies and conjunctivitis
Patel (1980)	Sri Lanka national infants	% households with: *water source *latrine type *floor/roof/walls *electricity	infant deaths	Ecol. study 15 regions	nil	no correlation of IMR with health services expenditures; negative correlation with well water, cement floor, tiled roof, brick walls and presence of electricity; positive correlation with river water and no latrine (univariate analysis)
Guerrant et al (1983)	NE Brazil rural/urban children < 5	5 groups varying in water (pipe/well/ river);toilets (nil/ pit/flush); urban/ rural; poor/non-poor	incidence rate of diarrhea (daily records + stool cultures)	Cohort study x 30 months 55 HH; 297 people	nil	highest attack rate in group with river source, no toilet and rural; lowest rate in group with piped water flush or pit toilets and urban non-poor
Butz et al (1984)	Malaysia national household sample	piped water toilets	infant deaths n = 5471	XSS, part of 1976 Family Life Survey of 1262 women	age, breast-feeding	water, sanitation, breast-feeding all independently associated with infant deaths; water stronger factor than sanitation; among infants exclusively breast-fed x 6 months, sanitation and water had no effect

Ryder et al (1985)	Panama, 2 islands inhabited by Cuna Indians (pop 1500)	water quantity	diarrhea, resp infections Scabies/impetigo	Cohort study	nil supposedly comparable	Both islands lacked fresh water; 1 received new central supply, with substantial increase in consumption (3 x the other island); decrease in skin infections but no change in resp infection; diarrhea actually increased (water clean at source but contaminated in home storage)
Rahman et al (1985)	Bangladesh 2 villages infants	tubewells, latrines, household size	infant deaths: neonatal (NM) and postneonatal (PNM)	Cohort study 2471 births	SES maternal age	NM not affected; PNM: RR=3.1 for no latrines and 1.5 for 10+ people per household
Hebert (1985)	Madras, India urban, coastal fishing families	water quality (coliform counts); quantity & storage; house quality; food preservation/cooking sanitary facilities and practices	anthropometric indices of nutritional status	Cohort study 12 months n = 627 children < 6	restricted to 1 caste; SES, breast-feeding, age	< 3 years: water quality more important than quantity; > 3 years, quantity more important determinant of nutritional status
Waxler et al (1985)	Sri Lanka, 3 rural districts infants	housing (no. rooms) water supply latrine type	infant deaths	XSS 480 HH	SES, health/ nutritional status and practices; ethnicity	path analysis showed best explanatory model to be: minority group status -> lack of sanitation -> infant death
Bersh & Osorio (1985)	Colombia, urban (pop 200,000) children < 5	water quality: residual chlorine, % days/month adequate level; % days at risk	notifications of diarrhea cases	Ecol. study (time trend: monthly 1978-82	nil	diarrhea rate correlates with % days per month unprotected (r = 0.47); by year, ave.annual residual chlorine level r ranged from -0.1 to -0.8

Table 8.2 Environmental Classification of Excreta-Related Infections

Cate-gory	Epidemiological feature	Infection	Dominant transmission	Major control measure
I	non-latent, low infective dose	Enterobiasis Enteroviruses Hymenolepiasis Amebiasis Giardiasis Balantidiasis	personal domestic	domestic water supply health education improved housing provision of toilets
II	non-latent, medium or high infective dose, moderately persistent and able to multiply	Typhoid Salmonellosis Shigellosis Cholera E.coli Yersiniosis Campylobacter	personal domestic water crop	domestic water supply health education improved housing provision of toilets treatment prior to discharge or reuse
III	latent and persistent with no intermediate host	Ascariasis Trichuriasis Hookworm	yard field crop	provision of toilets treatment of excreta prior to land application
IV	Latent and persistent with cow/pig intermediate host	Taeniasis	yard field fodder	provision of toilets treatment of excreta prior to land application cooking meat inspection
V	Latent and persistent with aquatic intermediate host(s)	Clonorchiasis Fascioliasis Fasciolopsiasis Diphyllobothriasis Gastrodiscoidiasis Heterophyiasis Metagonimiasis Paragonimiasis Schistosomiasis	water	provision of toilets treatment of excreta prior to discharge control of animal reservoirs cooking
VI	Excreta-related insect vectors	Filariasis + all infections in I-V for which flies & cockroaches can be vectors	various fecally contaminated sites in which insects breed	identification and elimination of suitable breeding sites

Source: adapted from Feachem et al (1981)

Table 8.3 Diseases Related to Deficiencies in Water Supply or Sanitation

Group	Diseases	Route of exit/entry	Relevant measures
Waterborne diseases	Cholera	F / O	improve quality, aim for maximum micro-biological quality of water, improve sanitation
water as passive vehicle; contamination occurs through poor sanitation	Typhoid	F,U / O	
	Leptospirosis	U,F / P,O	
	Giardiasis	F / O	
	Amebiasis	F / O	
	Hepatitis A	F / O	
Water-washed diseases	Scabies	C / C	improve quantity, provide greater water volume, facilitate access, encourage its use; improve sanitation, personal hygiene
inadequate quantity of water and poor personal hygiene favour spread; intestinal infections also relate to lack of proper excreta disposal	Skin sepsis	C / C	
	Yaws	C / C	
	Leprosy	N? / ?	
	Lice/Typhus	B / B	
	Trachoma	C / C	
	Conjuntivitis	C / C	
	Bac.dysentery	F / O	
	Salmonellosis	F / O	
	Enteroviruses	F / O	
	Paratyphoid	F / O	
	Ascariasis	F / O	
	Enterobiasis	F / O	
Water-based diseases	Schistosomiasis	U,F / P	reduce contact with infested water, protect source, improve sanitation
necessary part of life cycle in aquatic animal	Dracunculosis	C / O	
Water-related vectors	Yellow fever	B / B	clear vegetation, avoid need to visit source; provide reliable supply; eliminate stagnant water
spread by insects that breed in water or bite near it; unaffected by waste disposal	Dengue	B / B	
	Arboviruses	B / B	
	Filariasis	B / B	
	Malaria	B / B	
	Onchocerciasis	B / B	
	Sleep. sickness	B / B	
Fecal disposal dis.	Clonorchiasis	F /fish	proper fecal disposal; eat well-cooked fish
	Diphyllobothr.	F /fish	
	Fasciolops.	F /edible plant	
	Paragonim.	F,S/crayfish	

Source: adapted from White, Bradley and White (1972), World Bank (1976), and Cairncross et al (1980)

Notes: F = feces, O = oral, U = urine, P = percutaneous, c = cutaneous
B = bite, N = nose, S = sputum

(1) Lack of adequate control: either the complete absence of an external comparison (control) group, or if one is chosen, the comparability of the two groups for the health indicators under consideration is not established prior to the intervention.

(2) One-to-one comparison: two communities, one with the intervention and the other without, are compared. The effective sample size is only two, as each individual or household is not an independent unit of study and the sampling unit is really the community.

(3) Confounding variables: SES, personal hygiene, educational level are common confounders in studies on water and sanitation.

(4) Health indicator recall: particularly in studies of infant diarrhoea which depend on parents' recall of the events within a prescribed period. False positive responses may be due to fear of the interviewer, the promise of medical treatment, or a wish to please the interviewer. False negative responses may be due to embarrassment and shame about a "dirty" disease.

(5) Health indicator definition: precise definition of what constitutes a "case" is needed. Clinical disease and subclinical infection also needs to be differentiated.

(6) Failure to analyze by age: an age-specific approach should be used since different age groups are at risk for different health outcomes.

(7) Failure to record facility usage: just because a facility has been installed does not mean that it has been used. Self reports of use may need to be substantiated by direct observation.

(8) Seasonality: the incidence of many of the diseases vary according to seasons of the year, which must be taken into consideration to avoid incorrect conclusions regarding the presence or absence of effect.

8.4 Policy Implications

Despite the lack of adequate studies, the weight of evidence is in favour of the beneficial health impacts following improvements in water and sanitation. According to Esrey and Habicht's recent critical review (with 96 citations), excreta disposal consistently appears to play a more important role in determining children's health than do water supplies. However, they also regarded increasing the use of water for domestic hygiene practices as a priority. Even when the quantity is available, education is needed to promote hand washing and home cleaning. The emphasis on water quality may be questioned. The evidence suggests that water quantity is more important than quality. High standards for water quality are unrealistic in many locations, and they should only become a priority after improvements in excreta disposal and water quantity have been achieved.

Within international development circles, a debate has been raging for some time over the proposal for "selective primary health care". Water supply and sanitation were included in the Primary Health Care (PHC) package proposed by WHO. However, some health policy analysts argued that insufficient resources were available to implement all the components of PHC (Walsh and Warren 1979). They suggested instead that as an interim strategy only the most cost-effective interventions in reducing infant mortality should be given priority. Such "selective" PHC include oral rehydration therapy, immunizations, malaria treatment and breast-feeding. Water and

sanitation were deemed not cost- effective enough.

The objections to selective PHC have been reviewed by Rifkin and Walt (1986). From a philosophical perspective, selective PHC consists entirely of "medical" interventions and fails to address equity and community involvement. Briscoe (1984) challenged the assumptions used in the calculations which concluded that water and sanitation were not cost-effective. Because water and sanitation projects have multiple outcomes, care needs to be exercised in applying conventional cost-effectiveness techniques. Water supply and sanitation are "necessary" but not "sufficient" conditions for improvement of health status, which may not be evident immediately.

Shuval et al (1981) advanced the "threshold-saturation" theory, which states that at low level of economic development, there is an initial lag phase where little health improvement can be expected despite improvements in water supply and sanitation. At the other end of the scale, in highly developed situations, further refinements of sanitation facilities are also unlikely to increase health. This has relevance to Canada, since we do seem to have an "undeveloped" situation on Indian reserves within a highly affluent society in general. The problem is we do not know where exactly in the spectrum moving from self-haul of water to street standpipes, or graduating from pit privies to indoor toilets, fits. It is reasonable to believe that such moderate technological advances are unlikely to be at the saturation end or still remain below the threshold. Kawata (1978), in his "minimum investment concept", warned against the fallacy that any measures are better than none. At some low levels of infrastructure investments, health risks can actually be increased.

Regardless of the magnitude of the gains in health, investments in water, sanitation, and housing on Canadian Indian reserves serve an important social objective, that of redressing inequity. How this objective is achieved is almost as important as whether this objective is achieved. For years Indian communities have rarely been consulted regarding the need for and the most appropriate type of sanitation facilities. The design and execution of such projects are considered purely technical matters. "Community participation is often only partial community concurrence" (McGarry et al 1980). The controversy surrounding the Big Trout Lake, Ontario, sewage disposal project in the late 1970s served as a case study in self-determination, and the melding of external technical expertise with local knowledge. In the end, the users made the choices (Jackson et al 1979).

8.5 Chemical Characteristics of Drinking Water

The previous sections on water and sanitation deal mainly with bacteriological contamination of water as a health hazard. Increasingly it is recognized that the presence in drinking water of some chemical substances may also constitute a danger to health. Chemical contamination of water sources may occur through water pollution (from industrial emissions, toxic spills, and pesticide runoff for example); high levels of some chemicals may be present in some water from naturally occurring sources; water treatment may lead to high levels of some chemicals; and in one case, that of flouride, this chemical is purposely added to drinking water at carefully controlled concentrations for health reasons. Specifically it has been shown that the presence of small amounts of flouride in drinking water leads to a substantial reduction of dental carries, particularly among children. The optimal concentration of flouride is 1.0 mg/l to 1.2 mg/l, with the maximum acceptable concentration of 1.5 mg/l, to avoid dental flourosis, a condition characterized by mottling teeth enamel, due to excess.

Canadian drinking water standards have been developed for some inorganic and organic chemical substances which may be hazardous to health if present above these concentrations in drinking water (see Table 8.4). In general, these levels have been derived by assessing the possibility of adverse effects after prolonged exposure; some of these are controversial and/or are under revisions. Also, the limits for these substances should be related to the daily intake of drinking water as well. Ideally, chemical contaminants (for which a maximal acceptable concentrations has been established due to potential adverse health effects), should be absent from drinking water supplies. Table 8.4 shows the recommended limits for chemical substances related to health as stated in the Guidelines for Canadian Drinking Water Quality (1978). The maximum acceptable concentration of lead, for example, is the subject of current controversy, as noted above. The presence of mercury in water has been the cause of concern in some Indian reserves, particularly as organic mercury is bioconcentrated by fish. Elevated mercury levels have been found in all fresh water fish taken from areas with suspected mercury contamination and frequently rendered the fish unacceptable for human consumption. Long-term daily ingestion of approximately 0.25 mg of mercury as methylmercury has caused the onset of neurological symptoms. (The rationale for the numbers provided in Table 8.4 is provided in the guidelines and supporting documentations for these guidelines.)

Generally natural substances make up the greatest proportion of organic matter and are generally not in themselves likely to pose a health hazard. The synthetic organic chemicals also can be divided into those substances, such as trihalomethanes, that result from water treatment practices; and those contaminants introduced into water from point and non-point sources of pollution. Household products contain many soluble organic chemicals that find their way to septic tanks, from where they migrate to the water table; some products used for cleaning septic tanks may also be problematic (Miller 1981). The health effects of water contamination by waste chemicals has been extensively reviewed (Grisham 1986, Yassi et al 1990).

In addition to specific organic contaminants, it is recommended that water treatment plants monitor the general level of organic matter. It is desirable that drinking water be free of pesticides and every effort should be made to prevent pesticide pollution of raw water sources. Trihalomethane is present in drinking water primarily as a result of the reaction of the chlorine applied for disinfection with organic substances that naturally occur in the raw water. Chloroform, the most commonly found trihalomethane in drinking water may increase the development of malignant tumors (Shy 1985, Wilkins et al 1979). Trihalomethane levels in surveyed public water supplies in Canada are generally well below the maximum acceptable concentration. Also, total organic carbon (TOC) is often measured in drinking water. High levels of TOC are commonly due to the presence of naturally occurring organic matter. Although not necessarily a health hazard, high levels may be associated with color, taste, odor and turbidity problems. It should be noted, however, that some water with a low TOC may be contaminated with low but hazardous concentrations of toxic organic chemicals.

9. Indoor Air Quality

9.1 Introduction

Indoor air quality (IAQ) refers to the physical, chemical and biological characteristics of indoor air. Where indoor air quality is compromised in workplaces or in homes, non-specific symptoms of discomfort and ill health, such as eye, nose and throat irritation, mental fatigue, headaches, non-specific hypersensitivities, and other complaints can occur (Interministerial Committee 1988).

Substance*	Maximum Acceptable Concentration mg/L	Objective Concentration mg/L
Inorganic		
Antimony	—	≤0.0002
Arsenic	0.05	≤0.005
Barium	1.0	≤0.1
Boron	5.0	≤0.01
Cadmium	0.005	≤0.001
Chromium	0.05	≤0.0002
Cyanide (Free)	0.2	≤0.002
Lead	0.05	≤0.001
Mercury	0.001	≤0.0002
Nitrate (as N)**	10.0	≤0.001
Nitrite (as N)**	1.0	≤0.001
Selenium	0.01	≤0.002
Silver	0.05	≤0.005
Sulphate	500	<150
Uranium	0.02	≤0.001
Organic		
Nitrilotriacetic Acid (NTA)	0.05	≤0.0002
Pesticides (Total)***	0.1	—
Trihalomethanes****	0.35	≤0.0005

* Unless otherwise stated the limits for each substance refer to the sum of all forms present.

** Where both nitrate and nitrite are present, the total nitrate- plus nitrite-nitrogen should not exceed 10 mg/L.

*** For maximum acceptable and objective concentrations of individual pesticides see Table 3.

**** Comprise chloroform, bromodichloromethane, chlorodibromomethane, and bromoform.

Table 8.4 Recommended Limits for Chemical Substances Affecting Health

[Source: Reproduced from Federal-Provincial Working Group on Drinking Water (1978)]

With long cold winters and hot summers, considerable time is spent indoors. With the increasing use of synthetic materials and alternative heating systems, and a trend to tighter, more fuel-efficient housing there has been increased attention to this area (Federal-Provincial Advisory Committee 1987, Morris et al 1990).

The quality of indoor air is influenced by outdoor sources and indoor sources: combustion processes, building products and human activities (Interministerial Committee 1988, Health and Welfare Canada 1987). Indoor air quality is also influenced by the amount of fresh air that circulates and the size of the house - the tighter and smaller the house, the higher the contaminant level (Petreas et al 1988, Traynor et al 1988). There are a large number of materials found in indoor air. More than 250 different organic compounds have been measured in indoor environments (Tichenor and Mason 1988).

Energy conservation and new construction methods result in less outdoor air entering the home. This results in greater differences between indoor and outdoor air qualities. Where contaminants are generated outside the home, this will result in improved indoor air quality. Where the contaminants are generated inside the home, this will result in reduced indoor air quality. In the spring and fall when houses are more likely to be open, indoor air quality will be similar to outdoor air quality (Yocom 1982).

Indoor air quality will be reduced if the air exchange rate in a house is reduced while the generation rates of contaminants remain constant. If the generation rates can be reduced, there may be an improvement in indoor air quality when the air exchange rates go down. Where improved insulation is used to reduce air infiltration rates, there will also be a reduced need for space heating. With a reduction in this source of contaminants, it is possible to improve indoor air quality. However, other contaminants that are generated in the home, such as those from building materials, furnishings and household chemicals, may increase with a reduced air exchange rate (Traynor et al 1988, Cohen et al 1989).

Indoor pollutants can be removed by conversion to other materials, deposition of particulate materials, absorption and adsorption of gasses and vapours, and dilution (Yocom 1982).

9.2 Sources of Indoor Pollutants

The following are examples of materials, activities and conditions that can affect indoor air quality.

(1) Heating and Cooking Sources

Wood-burning stoves can emit particulates, oxides of sulphur, nitrogen oxide, hydrocarbons, carbon monoxide, polycyclic organic hydrocarbons, formaldehyde, acetaldehyde, phenols, acetic acid, and water vapour (Federal-Provincial Advisory Committee 1987, Morris et al 1990, Spengler 1990, Yocom 1982). Wood-burning stoves have also been specifically connected with respiratory infections (Morris et al 1990, Pierson et al 1989). [It should be noted that the study by Morris is one of the few studies conducted in an American Indian population].

Kerosene heaters are used for space heating and are often unvented even though manufacturers recommend providing ventilation by opening a window to the outside or by opening a door to an adjoining room. Using an oversized heater or operating a heater in a smaller room than that for

which it was intended will result in high and possibly unsafe concentrations of air pollutants. These heaters can emit oxides of sulphur, carbon monoxide, nitrogen oxides, particulates, and water vapour (Interministerial Committee 1988, Federal-Provincial Advisory Committee 1987, Yocom 1982, Ritchie and Oatman 1983).

Gas fired stoves are not always vented, and products of combustion are given off from the ovens and pilot lights. Emissions include nitrogen oxides, aldehydes and carbon monoxide (Interministerial Committee 1988, Federal-Provincial Advisory Committee 1987). Several British and U.S. studies on indoor pollution effects showed that children are at special risk for nitrogen oxides induced acute respiratory disease. The U.S. Environmental Protection Agency (EPA) noted that even after correcting for potential confounding factors, a clear association existed between increased respiratory illness below age two, and the presence of gas cooking devices (Traynor et al 1985, Myers 1989).

(2) Furnishing, Materials and Household Chemicals

Furnishings made of synthetic materials can slowly degrade, releasing small quantities of the original material or byproducts. Draperies, rugs and fabrics can also release man-made fibres and microbiological contaminants. Furniture made of wood laminates or particleboard may release formaldehyde. Older fluorescent light fixtures may contain polychlorinated biphenols (Interministerial Committee 1988, Federal-Provincial Advisory Committee 1987, Yocom 1982, Tichenor and Mason 1988, Silberstein and Grot 1988).

Construction materials have both short term and long term effects. Adhesives, paints and sealants contain a wide range of solvents that are released during and shortly after application. Some of these materials are suspected irritants and carcinogens. Over the long term, plywood, particleboard, urea-formaldehyde insulation, adhesives, vinyl wall covering, and resin treated fabrics and insulation can release formaldehyde. These problems are greatest in new buildings; after they have "degassed" the hazard is reduced. Where asbestos is used as insulation or fireproofing, there is a risk of long term exposure to asbestos fibres in the home. Paints containing heavy metals such as lead, or mercury fungicides can result in long term exposures to occupants (Interministerial Committee 1988, Federal-Provincial Advisory Committee 1987, Yocom 1982, Tichenor and Mason 1988, Silberstein and Grot 1988, Spengler 1990).

Household chemicals used as cleaners, disinfectants, pesticides, deodorants, or lubricants can introduce a wide range of materials into the home. A partial list includes benzene, chloroform, diethylphthalate, ethylbenzene, methylene chloride, phenol, and trichloroethylene. Chemicals can also enter the home as a part of crafts or hobbies. Workplace chemicals can also enter the home on the clothing of occupants who work outside the home (Federal-Provincial Advisory Committee 1987, Spengler 1990, Cohen et al 1989).

(3) Cigarette Smoking

Cigarette smoking is unquestionably the most important human activity that effects the quality of air in homes. The well-known health effects of smoking will not be reviewed here. However, it is important to appreciate the effects of environmental tobacco smoke (ETS), previously called "second hand smoke". ETS is a combination of the smoke exhaled by people who smoke (or

exhaled from mainstream smoke), and smoke which is produced at the lit end of the cigarette or other burned tobacco product (sidestream smoke). ETS contains at least 3800 chemicals, of which over 50 are known cancer causing substances in animals, humans or both (Collishaw et al 1984). Some substances which are found in ETS include formaldehyde, carbon monoxide, hydrogen cyanide, ammonia, nicotine, aniline, naphthalene and arsenic. In fact, much higher levels of ammonia, nitrogen oxide and the highly carcinogenic N-nitrosamines are found in sidestream smoke than in mainstream smoke (National Research Council 1986).

The most common immediate effect of exposure to ETS are irritation of the eyes, nose and throat, and reactions to the smell (Galloway 1986). Pregnant women exposed for at least 2 hours per day to ETS produce babies with a lower birth weight than babies born to mothers who have no ETS exposure (Martin and Bracken 1986). A few studies have indicated that children with parents who smoke grow and develop more slowly than children of non-smoking parents (see Galloway 1986). Wheezing, coughing and sputum production are more common in children exposed to ETS than in children in non-smoking environments. Pneumonia and bronchitis are also more common. Several studies have found that children of parents who smoke have an increased risk of chronic ear infections. In general, children of parents who smoke are sicker than children whose parents do not smoke. These children have more days in bed and more hospitalizations than children not exposed to ETS. People with chronic diseases such as heart disease, lung disease and allergies can experience increased problems with exposure to ETS. People with allergies in particular find ETS more irritating to their eyes, nose and throat than those without allergies. Studies have also indicated that exposure to ETS can cause decreased lung function and increased risk of bronchitis, pneumonia and other respiratory infections (Galloway 1986). Some studies have also showed a link between exposure to ETS in childhood and increased risk of developing cancer as an adult (Janerich et al 1990). While exposure to ETS does not cause the same level of disease as smoking itself, the fact that people can develop short and long-term illnesses from exposure to ETS in the home is certainly noteworthy.

(4) Biological Agents

Microbiological organisms can be found in improperly maintained heating and ventilating systems, wet or damp rugs and furnishings. These organisms can cause upper respiratory symptoms, allergic reactions of the skin, and odours. Individuals with asthma can have their condition aggravated by moulds, mites, pollen, algae, insects and animal danders. An overgrowth of moulds and fungi have rendered some buildings uninhabitable, with clean up next to impossible. Low humidity, dust free surfaces, clean humidifier tanks, and good personal hygiene are needed to reduce the possibility of microbiological agents becoming a problem. Mild to moderate visible indoor mould growth has been found to have only a minor influence on the airborne mould flora inside the home, compared with dust-raising household activities such as cleaning. It has also been found that the relative humidity of a room is less significant for the growth of moulds than condensation on or in the walls due to lower wall temperature caused by poor insulation (Interministerial Committee 1988, Federal-Provincial Advisory Committee 1987, Strachan et al 1990, Hosein et al 1989, Strachan and Sanders 1989, Waegemaekers et al 1989).

(5) Radon

Radon is a pollutant that occurs naturally. Radon can be found in domestic water, natural gas,

underlying soil, and groundwater. The overwhelming portion is from radon gas infiltrating homes from the underlying rocks and soil. Radon generally diffuses into a home through the substructure, migrating to the upper floors. Highest levels are found in basements, and occur in the winter when ventilation is decreased. Decreased infiltration of fresh air will increase radon concentration in the home. The U.S. Environmental Protection Agency has judged radon to be the most serious category of environmental carcinogens to which the general public is exposed (Federal-Provincial Advisory Committee 1987, Puskin and Nelson 1989, Bierman et al 1989).

(6) Outdoor Sources

Air inside the house is replaced and mixed with outdoor air. The rate of air exchange is influenced by temperature, wind velocity, and humidity. The quality of this air affects the quality of the air inside the house. Unreactive pollutants such as carbon monoxide readily penetrate the house. Indoor sources such as unvented gas stoves may cause indoor concentrations to exceed those outdoors. Reactive gases such as ozone and sulphur dioxide are rapidly depleted after entering the house. Vehicular and industrial emissions are the major sources of outdoor pollutants, and urban concentrations are greater than rural. Where there is significant number of homes heated with wood, there appears to be a relationship among fine particle concentration in air, indirect acting mutagenicity, and polycyclic aromatic hydrocarbons. Common pollutants from outdoor sources include nitrogen oxides, particulates, lead, sulphur dioxide, ozone, pollens, calcium, chlorine, and silicon.

Table 9.1 lists alphabetically various indoor pollutants and their sources.

9.3 Health Effects of Indoor Pollutants

A wide range of health effects have been identified or suspected as a result of exposure to airborne contaminants found in indoor air. These are summarized in Table 9.2.

9.4 Methodological Issues in Risk Assessment

It is extremely difficult to conduct studies to assess the health effects of housing conditions. Even with a hazard inventory and population at-risk well-defined, the ability of a study to detect an effect when it is present (ie. the "power" of the study) is limited by numerous factors, including small sample sizes, low background rates of negative outcome, long latency periods, and the non-specificity of many of the potential health effects associated with various hazards.

The science of risk assessment, which can be brought to bear to address the question of "what is the probability of harm?", involves three basic preliminary steps:

(1) hazard identification
(2) characterization of diseases or other negative outcomes associated with the hazardous exposures identified
(3) dose-response or hazard assessment to determine the amount of disease associated with a given level of exposure to the hazard

Actual risk assessment for a specific community experiencing these hazards is based on

Table 9.1 Alphabetical Listing of Airborne Contaminants and Common Household Sources

Contaminant	Sources
Aldehyde	Wood-burning stoves, gas stoves, cigarette smoke
Acetic acid	Wood-burning stoves
Asbestos	Construction materials
Carbon monoxide	Wood-burning stoves, kerosene heaters, gas stoves, cigarette smoke
Formaldehyde	Wood-burning stoves, furnishings, construction materials, cigarette smoke
Microorganisms	Furnishings, human activity, animals
Nitrogen Oxide	Wood-burning stoves, kerosene heaters, gas-fired stoves, outdoor sources, cigarette smoke
Particulates	Wood-burning stoves, kerosene heaters, furnishings, outdoor sources, cigarette smoke
Phenols	Wood-burning stoves, household chemicals
Oxides of Sulphur	Wood-burning stoves, kerosene heaters, outdoor sources
Volatile organic hydrocarbons	Furnishings, household chemicals, wood-burning stoves, construction materials
Water vapour	Wood stoves, kerosene heaters, gas-fired stoves, cooking, human activity, animals

Table 9.2 Health Effects of Airborne Contaminants

Contaminant	Effects
Aldehyde	Eye irritation, upper respiratory tract irritation
Asbestos	Asbestosis, lung cancer, mesothelioma, other cancers
Carbon monoxide	Headache, nausea, breathlessness, dizziness, fatigue, low birth weight, cherry red lips, visual disturbances, cyanosis, mental confusion, angina, coma, death
Formaldehyde	Eye irritation, respiratory tract irritation, possible cancers
Microorganisms	Infectious diseases, allergic reactions in sensitized people
NO_x	Eye irritation, upper respiratory tract irritation, respiratory illness
Particulates	Eye irritation, upper respiratory tract irritation, suspected allergic reactions, increased mortality among elderly and those with preexisting respiratory and cardiovascular diseases
SO_x	Upper respiratory tract irritation, impaired pulmonary function, excess mortality among elderly and those with cardiopulmonary diseases
Volatile organic compounds	Headache, dizziness, upper respiratory tract irritation, nausea
Water vapour	
*low relative humidity	Dryness of skin, drying of mucous membranes, chapping, irritation, bronchoconstriction in asthma sufferers, possibly increased susceptibility to infectious agents
*high relative humidity	increase in moulds, fungi, and mites that may cause exacerbation of asthma

combining the basic hazard assessment with actual data on the extent of the hazard in the community in question.

Data sources which can be used to identify and assess the hazardous nature of exposures can be derived from human studies, including both formally planned epidemiological studies and accidental human exposures. Often our knowledge must come from animal tests, short-term laboratory tests, and for chemicals, by comparison of molecular structure with other known toxic substances.

Human Studies: These include case reports, case series, outbreak investigations, epidemiologic surveillance, and special surveys either initiated by the investigator or requested by an affected community. Without a comparison or control group, such studies are primarily descriptive. The various types of analytical studies such as cohort and case-control studies have been discussed in Chapter 7.5. Each has its own advantages and disadvantages and all are subject to various biases. In studies of the health effects of environmental hazards, a respondent who believes his headache has resulted from breathing chemicals may remember his headache better or be more prone to mention it than someone for whom a headache is just a minor annoyance of no particular consequence. Unfortunately such recall and reporting bias tends to increase with proximity to the source of exposure, just as one would expect biological effect to be strongest.

The success of epidemiological studies necessitates valid and accurate information regarding both the hazardous exposure and the biological abnormality or disease, both of which are usually difficult to measure in environmental health studies. Even with relatively good exposure and outcome data, the disease in question may take many years to develop. Many outcomes are nonspecific, i.e, could have been caused by a multitude of factors either separately or in combination.

Epidemiologists employ a set of criteria for inferring causation. None of these are absolute, but the more studies that satisfy some of these criteria the stronger is the weight of evidence in support of causation. These are: strength of association, temporal sequence, dose-response relationship, consistency with other studies, biological plausibility, and specificity of outcome

Animal/Laboratory Studies: As much of the evidence on the toxicity of chemical exposures comes from animal studies, it is important to recognize their limitations. First of all, there are species-to-species differences. Some substances known to be carcinogenic in rats do not appear to be carcinogenic in mice. Inferring carcinogenicity to higher mammals, particularly to human beings, would be suspect. Secondly, many issues arise in extrapolating from high dose exposure in animals to low dose exposure in humans. As the lifetime of laboratory animals is much shorter than that of humans, and as the number of people potentially exposed would be far larger than the number of animals that could be studied in laboratories, it is necessary that much higher doses be used in animal studies than humans would ever encounter in the environment, even in a worst case scenario.

Short-term laboratory tests have been very useful in evaluating toxicity, particularly in carcinogenic potential. These tests include those in which the suspected substance is applied to a culture medium in a laboratory plate to see if it causes a mutation which can be seen by changes in bacterial growth. These short-term tests can investigate not only gene mutation but also chromosome damage, and they could be further enhanced with actual tissue substances.

Because of the difficulties in interpreting animal and laboratory tests, a presumption exists that

a chemical which is structurally similar to a known carcinogen has a high probability of itself being a carcinogen. Although this is a prudent approach, the evidence supporting such associations is still quite limited.

As the evidence from epidemiological studies, animal experiments and short-term laboratory tests, and molecular comparisons all have serious limitations, establishing proof that a certain exposure is hazardous, let alone providing information for a dose-response estimate is extremely difficult. For most physical conditions and toxic substances, a "threshold" is assumed to exist, in other words, a certain level of exposure must be exceeded before health effects will occur. For most potential carcinogens, the generally accepted - and prudent - approach is to assume that no threshold exists. Nonetheless, the magnitude of the risk at low levels of exposure has long been highly contentious.

The final step in the process to determine "how much harm is probable" is to combine and integrate information from the literature with an assessment of exposure in the actual situation.

10. Safety in the Home and Community

10.1 Extent of the Problem

The extent and magnitude of the problem of injuries in Canada has been reviewed (Nicholls and Davies 1980, Riley and Paddon 1989). For Canadians under 45, accidents are the leading cause of both death and hospitalization. For the Canadian population as a whole, accidents rank fourth as a cause of death, after cardiovascular disease, cancer and respiratory disease. There has been substantial decrease in the age-standardized mortality rates for accidents between 1971 and 1986 - 44% for men and 39% for women (Riley and Paddon 1989). According to data from the Canada Safety Council, 44% of all non-transport accidental deaths occurred at home (57% for falls, 86% for fires, 56% for poisoning, 44% for firearms). Accidental deaths affecting adolescents and young adults occurred most frequently outdoors as a result of transport accidents. For adults aged 30 and over, the great majority (about 80%) occurred in homes and residences (Nicholls and Davies 1980).

10.2 Theoretical Issues in Injury Control

All injuries involve (1) a host (or victim), (2) an agent, which is one or more forms of physical energy: kinetic or mechanical, chemical, electrical, thermal and radiation, and (3) an environment, which includes both the physical and social environments (Waller 1985). Haddon made major contributions to the field of injury control when he advanced the concept of the pre-event, event and post-event phases of an injury, initially developed through work on motor vehicle traffic accidents (Haddon 1963). It should be emphasized that the term "accident" is disapproved of by injury researchers, who regard such events as non-random occurrences with preventable causes. The term "unintentional injury" is preferred. However, "accident" is too well established in common usage to be readily replaced by the ideologically more correct term. During the pre-event phase, the energy goes out of control. During the event phase, the amount of energy released and the manner of its transfer to the human body determines if an injury results and its severity. In the post-event phase physiologic regulatory mechanisms come into play and external factors such as emergency care, definitive treatment and rehabilitation will determine the final outcome. The three phases in one axis and the host/agent/environment on the other forms "Haddon's matrix",

which ensures that all potential strategies for intervention are considered. An example of the application of this matrix to house fires on Indian reserves (Friesen 1985) is given in the next Section.

Prevention can be realized through action on the different factors at any one of the phases. Haddon further identified 10 categories of countermeasures to prevent or mitigate the effects of injuries (Haddon 1973):

(1) Prevent the creation of the hazard in the first place.
(2) Reduce the amount of hazard brought into being.
(3) Prevent the release of an existing hazard.
(4) Modify the rate or spatial distribution of release of the hazard from its source.
(5) Separate, in time or in space, the hazard and that which is to be protected.
(6) Separate the hazard and that which is to be protected by interposition of a material barrier.
(7) Modify the basic qualities of the hazard.
(8) Make that which is to be protected more resistant to damage from the hazard.
(9) Counter damage already done by the hazard.
(10) Stabilize, repair, and rehabilitate the victim.

10.3 Accidents and Injuries among Native Canadians

North American Natives have one of the highest accidental and violent death rate in the world. While much of this excess mortality can be attributed to socioeconomic conditions and social stress, part of it also reflects inadequate housing and community infrastructure. The excessively high mortality rate from house fires (as much as 6-10 times higher than Canadians nationally) could be the result of unsafe woodstoves, lack of safety devices in the home, and inadequate fire protection services in the community. The high drowning rate, while indicative of the geographical location of many reserves and the dependence on boats for basic transportation, also suggests the faulty boat safety practices and lack of instruction. The easy access to firearms in the home in communities where hunting is still widely practised contributes to the high rate of firearm deaths, whether accidental or intentional. Housing probably also plays a role in many suicides and homicides, since crowding may contribute to an increase in interpersonal conflicts within the family and community. Alcohol abuse cannot always be confirmed since post-mortem blood alcohol levels are not always available. However, detailed sociological inquiries have provided further information on the circumstances surrounding "accidental" deaths, many of which are in fact associated with alcohol intoxication (Jarvis and Boldt 1982).

Table 10.1 summarizes several Canadian studies on injuries among Indians in which a "relative risk" estimate is provided.

In recent years injuries and deaths associated with off-road recreational vehicles have become increasingly of public health concern (Postl et al 1987). Motorbikes, snowmobiles and all-terrain vehicles are often essential means of transportation in northern Native communities. Hamby et al (1988) reviewed a case series of snowmobile accidents that resulted in hospital admissions in Labrador during one winter. The circumstances under which these accidents occurred suggested the importance of human factors: two-thirds occurred in clear weather, 60% of drivers had no drivers' license, one-third occurred on roads, only 10% were wearing helmets, 23% were under the influence of alcohol, and only 6% were due to mechanical failure.

Table 10.1 Risk of Mortality/Morbidity from Injuries among Native Canadians

ICD-9 Code	Disease	Author (Year)	Population/ Location	Relative Risk (Native/non-Native)
E800 -999	All Injuries	AWC-MSB (1988)	Canada: MSB service pop.	mortality (unadj): 1978-81 = 4.3, 1982-85 = 4.0
		Mao et al (1986)	IR, 7 prov. under 70 y.o.	SMR, 1977-82: M = 3.2, F = 3.7
		Young (1983)	NW Ontario Cree-Ojibwa	SMR, 1972-81: both sexes = 4.5
		Hislop et al (1987)	BC Indians	mortality (unadj): M = 3.7, F = 5.2
		Robinson (1988)	James Bay Cree, Quebec	SMR, 1975-81: both sexes = 2.0
		MacWilliams et al (1987)	IR, 7 prov. ages 1-14	SMR, 1977-82 = 3.2
E810 -819	Motor Vehicle Traffic Accidents	Mao et al (1986)	IR, 7 prov. under 70 y.o.	SMR, 1977-82: M = 2.3, F = 2.7
		Young (1983)	NW Ontario Cree-Ojibwa	SMR, 1972-81: both sexes = 1.0
		Hislop et al (1987)	BC Indians	mortality (unadj): M = 2.7, F = 4.2
		MacWilliams et al (1987)	IR, 7 prov. ages 1-14	SMR, 1977-82 = 1.6
E850 -869	Accidental Poisoning	Hislop et al (1987)	BC Indians	mortality (unadj): M = 2.4, F = 4.4
E880 -888	Falls	Mao et al (1986)	IR, 7 prov. under 70 y.o.	SMR, 1977-82: M = 2.4, F = 2.3
		Young (1983)	NW Ontario Cree-Ojibwa	SMR, 1972-81: both sexes = 1.0
		Hislop et al (1987)	BC Indians	mortality (unadj): M = 2.0, F = 2.3
		MacWilliams et al (1987)	IR, 7 prov. ages 1-14	SMR, 1977-82 = 2.5
E890 -899	Fires	Mao et al (1986)	IR, 7 prov. under 70 y.o.	SMR, 1977-82: M = 5.6, F = 6.9
		Young (1983)	NW Ontario Cree-Ojibwa	SMR, 1972-81: both sexes = 10.8
		Hislop et al (1987)	BC Indians	mortality (unadj): M = 9.4, F = 11.7
		MacWilliams et al (1987)	IR, 7 prov. ages 1-14	SMR, 1977-82 = 6.1
		Friesen (1985)	Manitoba Indians	SMR, 1971-81: M = 4.1, F = 5.2 Stand.hosp.rate: 4.5
E910	Drownings	Mao et al (1986)	IR, 7 prov. under 70 y.o.	SMR, 1977-82: M = 5.6, F = 2.4
		Young (1983)	NW Ontario Cree-Ojibwa	SMR, 1972-81: both sexes = 6.5
		Hislop et al (1987)	BC Indians	mortality (unadj): M = 6.0, F = 7.8
		MacWilliams et al (1987)	IR, 7 prov. ages 1-14	SMR, 1977-82 = 4.4
		Robinson (1988)	James Bay Cree, Quebec	SMR, 1975-81: both sexes = 10.0
E950 -959	Suicide	Mao et al (1986)	IR, 7 prov. under 70 y.o.	SMR, 1977-82: M = 2.7, F = 2.7

	Young (1983)	NW Ontario Cree-Ojibwa	SMR, 1972-81: both sexes = 1.8
	Hislop et al (1987)	BC Indians	mortality (unadj): M = 1.9, F = 1.6
E960 Homicide -969	Mao et al (1986)	IR, 7 prov. under 70 y.o.	SMR, 1977-82: M = 7.8, F = 5.8
	Young (1983)	NW Ontario Cree-Ojibwa	SMR, 1972-81: both sexes = 9.4
	Hislop et al (1987)	BC Indians	mortality (unadj): M = 10.5, F = 9.8

Notes: SMR = standardized mortality ratio
SIR = standardized incidence ratio
unadj. = unadjusted for age/sex (simple ratio)

The importance of house fires in Native communities is evident from Table 10.1, which shows the excess risk of death and hospitalization. The number of fires and property loss from fires in Canadian Indian reserves has been mentioned in Section 4.3 earlier in this report. The death rate from fires has been steadily declining by about 5% per year (Figure 10.1).

Friesen (1985) conducted one of the more detailed investigations of housefires among Manitoba Indians. The actual causes of the fires, in descending order of importance, include: faulty woodstoves, use of candles, smoking-related, use of electrical appliances, electrical wiring, children playing with fire, and deliberate suicide. However, it is possible to identify additional risk factors, divided into those relating to the host, the agent, and the physical and social environments (Table 10.2).

Friesen applied to his descriptive data Haddon's three-phase approach to injury prevention (Haddon 1980):

Pre-event Phase: this would be aimed at modifying the host's behaviour (eg. drinking and smoking), substituting safer forms of heating and lighting than woodstoves and candles, prohibition of alcohol in the community.

Event Phase: safety education on procedures during fire, installation of smoke detectors and fire extinguishers in the home, community water supply, formation of volunteer fire brigade.

Post-event Phase: first-aid treatment for burns, medical transportation of the critically injured.

These are potential strategies which require to be priorized according to the prevalence of the problem and the effectiveness of the intervention. Thus, if alcohol is involved in 50% of the fires but there is no effective means to reduce alcohol use, then it would be a poor choice as a major thrust of a fire prevention program. Prevention can also be active (which requires individuals to take specific actions) or passive (which does not require individual action in order to be protected). Generally, emphasis on individual education to alter behaviour alone is not adequate. It must be combined with "passive" measures relating to product modification and environmental re-design.

Table 10.2 Factors Associated with Fatal House Fires among Manitoba Indians 1976-82

Host:	Smoking, drinking, children unattended, suicidal intent
Agent:	Candles, oil burners, electrical appliances, wiring
Physical environment:	Combustible materials, blocked exits, malfunctioning extinguishers, flammable clothings and mattresses, lack of piped water
Social environment:	Disconnected electricity for non-payment, prevalence of alcoholism, lack of fire department, non-adherence to building codes, lack of child care/mental health programs

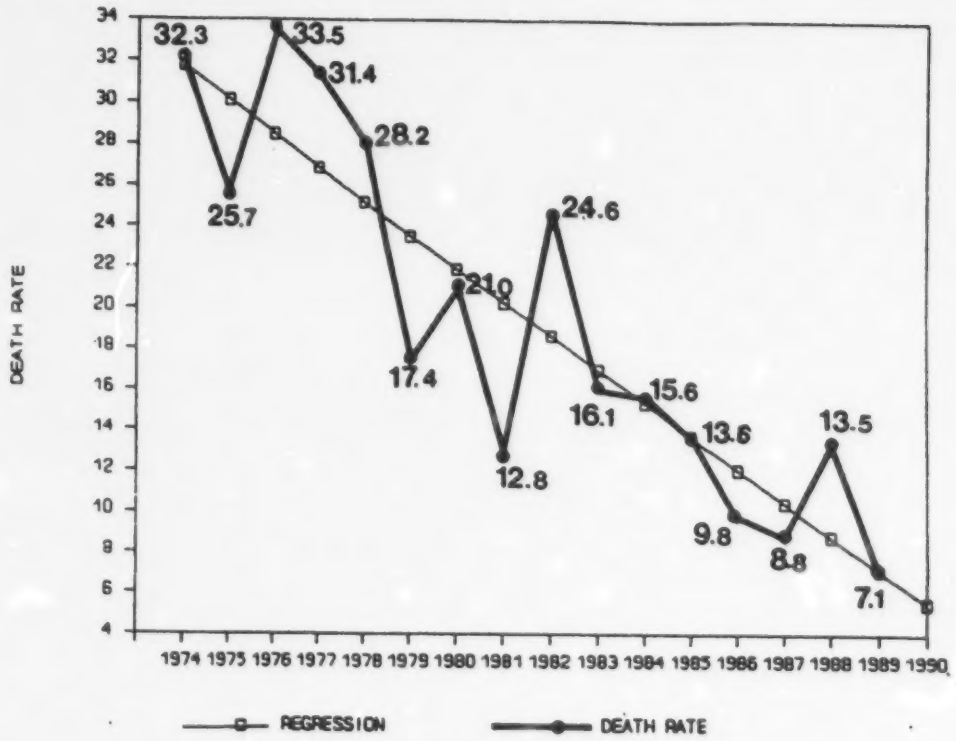


Figure 10.1 Decline in Death Rate from Fires in Indian Reserves, 1974-89.

[Source: DIAND, Fire Loss Report - 1989]

PART FOUR STANDARDS AND PRINCIPLES OF HEALTHFUL HOUSING

11. Contributions of the American Public Health Association

Since the 1930s the American Public Health Association (APHA) has been the major organization which promotes the establishment of standards on housing and guidelines to evaluate its quality and impact on health. In 1937 it established the Committee on the Hygiene of Housing, at the request of the Housing Commission of the League of Nations Health Organization, predecessor of the WHO (Winslow 1947). This committee was chaired by C.-E.A. Winslow, a leading figure in American public health. The aims of the Committee were twofold:

(1) to develop technical and administrative tools for housing improvement - standards based on public health knowledge, means for evaluating departures from such standards, and legal and administrative procedures for the regulation and improvement of housing;

(2) to encourage cooperation between housing and public health professionals in a comprehensive attack on the housing problem (Winslow 1947).

The first output of the Committee was the Basic Principles of Healthful Housing published in 1938 and revised in 1941. The report outlined 28 health needs essential to providing a healthful environment for the family (Cited in Pond 1964). These could be grouped under four headings:

(1) Fundamental physiological needs

* Maintenance of a thermal environment which will avoid undue heat loss from the human body
* Maintenance of a thermal environment which will permit adequate heat loss from the human body
* Provision for admission of direct sunlight
* Provision of an atmosphere of reasonable chemical purity
* Provision of adequate daylight illumination and avoidance of undue daylight glare
* Provision of adequate artificial illumination and avoidance of glare
* Provision against excessive noise
* Provision of adequate space for exercise and for the play of children

(2) Fundamental psychological needs

* Provision of adequate privacy for the individual
* Provision of opportunities for normal family life
* Provision of opportunities for normal community life
* Provision of facilities which make possible the performance of tasks of the household without undue physical and mental fatigue
* Provision of facilities for maintenance of cleanliness of the dwelling and of the person
* Concordance with prevailing social standards of the community

(3) Protection against contagion

* Provision of a water supply of safe sanitary quality, available to the dwelling
* Protection of the water supply system against pollution within the dwelling
* Provision of toilet facilities to minimize the danger of transmitting disease
* Protection against sewage contamination of the interior surfaces of the dwelling
* Avoidance of insanitary conditions in the vicinity of the dwelling
* Exclusion from the dwelling of vermin which may play a part in the transmission of disease
* Provision of facilities for keeping milk and food undercomposed
* Provision of sufficient space in sleeping rooms, to minimize the danger of contact infection

(4) Protection against accidents

* Erection of the dwelling with such materials and methods of construction as to minimize danger of accidents due to collapse of any part of the structure
* Control of conditions likely to cause fires or to promote their spread
* Provision of adequate facilities for escape in case of fire
* Protection against danger of electrical shocks and burns
* Protection against falls and other mechanical injuries in the home
* Protection of the neighbourhood against the hazards of automobile traffic

In 1948 another influential document was produced by the Committee, entitled Planning the Neighbourhood. [This was one of three monographs in the Standards for Healthful Housing series. Other titles were Planning the House for Occupancy (1950) and Construction and Equipment of the House (1951)]. It recognized the neighbourhood as a planning unit and stated:

...the neighbourhood concept implies that adequate housing consists not merely of the individual homes, no matter how well planned or how well located; but that all residential and community facilities and services required for the shelter, health and convenience of the residents of a neighbourhood must be included...

Standards for housing environment must deal at least with the smallest geographic unit which includes those basic facilities and conditions; a unit which will permit organization of physical surroundings to eliminate inconveniences and hazards; and which will provide a physical form suitable for the full development of community life... (Cited in Adams 1949)

The significant health principles which should be met in an adequate community environment are as follows:

(1) Protection against accident and communicable disease hazards, including provision for maintaining cleanliness;
(2) Provision of adequate daylight, sunshine, and ventilation with non-polluted air;
(3) Protection against excessive noise;
(4) Protection from fatigue and provision of reasonable privacy for the family;
(5) Provision of opportunities for normal family and community life in aesthetically satisfactory surroundings protected against moral hazards (Cited in Pond 1949).

In 1952 the Committee published A Proposed Housing Ordinance, based upon the Basic Principles and the Standards monographs. The Ordinance underwent several revisions and name changes. It became the APHA-CDC Recommended Housing Maintenance and Occupancy

Ordinance in 1967 and 1969. The 1971 edition was called Housing: Basic Health Principles and Recommended Ordinance, the 1975 edition APHA-CDC Recommended Housing Maintenance and Occupancy Ordinance. The most recent revision was Housing and Health: APHA-CDC Recommended Minimum Housing Standards (Wood 1986).

The APHA documents were widely used in setting standards in many jurisdictions and taught extensively in schools of public health, planning and architecture. The standards proposed were "performance" standards rather than "specification" standards as exemplified by various building codes and regulations. Building codes regulate the construction of buildings to sustain safely the loads expected from the type of occupancy and to be reasonably safe for such occupancy against fire and similar hazards. Housing standards, on the other hand, define the health requirements of "decent housing" and ensure that the dwelling is safe, sanitary and fit for human habitation (Wood 1986).

Apart from setting standards, the APHA also produced a manual for the appraisal of housing quality. Beginning in 1945 the Committee produced the 5-volume An Appraisal Method for Measuring the Quality of Housing. It set out conditions under which a basic deficiency in the quality of a dwelling was said to exist:

(1) Contaminated water supply
(2) Water supply outside unit or structure
(3) Toilet shared or outside the structure
(4) Bath shared or outside the structure
(5) Crowding of more than 1.5 persons per habitable room
(6) Crowding of sleeping rooms [(2 x no. of sleeping rooms)+ 2]
(7) Less than 40 sq.ft. of sleeping area per person
(8) Lack of dual egress
(9) Installed heating lacking in three-quarters of rooms
(10) Lack of installed electricity
(11) Rooms lacking windows
(12) Serious deterioration

Any dwelling containing 4 or more basic deficiencies is considered to represent an "extreme slum" (Pond 1949). [One has to wonder how Canadian Indian reserves in the 1990s would fare under such 1940s criteria!].

The APHA appraisal method has been used to formulate housing policy and plan improvements in specific localities. It classified four groups of areas:

(1) Areas in which the dwellings and their environment meet an accepted local minimum standard of quality;
(2) Areas with moderately advanced blight but in which the dwellings and environment can be restored to an acceptable minimum standard by the enforcement of suitable legislation;
(3) Areas in which the dwellings are so poor that it would not be feasible to restore them to an acceptable minimum standard, making it advisable to demolish them or convert to other uses;
(4) Areas in which the environment is so poor that they should be cleared of housing and replanned for other uses regardless of existing quality of dwellings (Cited in Timboni 1949).

In 1969 the APHA Program Area Committee on Housing and Health produced a considerably expanded set of "basic principles" which superseded the original 1938 version. It reflected changing views of the concept of personal and community health. The outline of Basic Health Principles of Housing and Its Environment is reproduced below:

I. Living Unit and Structure

A. Human Factors

1. Shelter against the elements
2. Maintenance of a thermal environment which will avoid undue but permit adequate heat loss from the human body
3. Indoor air of acceptable quality
4. Daylight, sunlight, and artificial illumination
5. In family units, facilities for sanitary storage, refrigeration, preparation, and service of nutritional and satisfactory foods and meals
6. Adequate space, privacy and facilities for the individual, and arrangement and separation for normal family living
7. Opportunities and facilities for home recreation and social life
8. Protection from noise from without, from other units, from certain other rooms, and control of reverberation noises within housing structures
9. Design, materials and equipment which facilitate performance of household tasks and functions without undue physical and mental fatigue
10. Design, facilities, surroundings, and maintenance to reproduce a sense of mental well-being
11. Control of health aspects of materials

B. Sanitation and Maintenance

1. Design, materials, and equipment to facilitate clean, orderly, and sanitary maintenance of the dwelling, and personal hygiene of the occupants
2. Water piping of approved safe materials with installed and supplied fixtures which avoid introducing contamination
3. Adequate private sanitary toilet facilities within family units
4. Plumbing and drainage system designed, installed and maintained so as to protect against leakage, stoppage or overflow and escape of odours
5. Facilities for sanitary disposal of food waste, storage of refuse, and sanitary maintenance of premises to reduce the hazard of vermin and nuisances
6. Design and arrangement to properly drain roofs, yards and premises, and conduct such drainage from the buildings and premises
7. Design and maintenance to exclude and facilitate control of rodents and insects
8. Facilities for the suitable storage of belongings
9. Program to assure maintenance of the structure, facilities, and premises in good repair and in a safe and sanitary condition

C. Safety and Injury Prevention

1. Construction, design, and materials of a quality necessary to withstand all anticipated forces which affect structural stability
2. Construction, installation, materials, arrangement, facilities, and maintenance to

minimize danger of explosives and fires or their spread

3. Design, arrangement and maintenance to facilitate ready escape, in case of fire or other emergency
4. Protection against all electrical hazards, including shocks and burns
5. Design, installation and maintenance of fuel-burning and heating equipment to minimize exposure to hazardous or undesirable products of combustion, fires or explosions, and to protect persons against being burned
6. Design, maintenance, and arrangement of facilities, including lighting, to minimize hazards of falls, slipping, and tripping
7. Facilities for safe and proper storage of drugs, insecticides, poisons, detergents, and deleterious substances
8. Facilities and arrangements to promote security of the person and belongings

II. Residential Environment

A. Community or Individual Facilities

1. An approved community water supply or, where not possible, an approved individual water supply system
2. An approved sanitary sewerage system, or where not possible, an approved individual sewage disposal system
3. An approved community refuse collection and disposal system, or where not possible, arrangements for its sanitary storage and disposal
4. Avoidance of building on land subject to periodic flooding, and adequate provision for surface drainage to protect against flooding and prevent mosquito breeding
5. Provision for vehicular and pedestrian circulation for freedom of movement and contact with community residents while adequately separating pedestrians from vehicular traffic
6. Street, through-highway location and traffic arrangements to minimize accidents, noise and air pollution
7. Provision of such other services and facilities as may be applicable to the particular area, including public transportation, schools, police, and fire protection, electric power, health, community, and emergency services
8. Community housekeeping and maintenance services, like street cleaning, tree and parkway maintenance, weed and rubbish control, and other service requisite to a clean and aesthetically satisfactory environment

B. Quality of the Environment

1. Development controls and incentives to protect and enhance the residential environment
2. Arrangement, orientation, and spacing of building to provide for adequate light, ventilation, and admission of sunlight
3. Provision of conveniently located space and facilities for off-street storage of vehicles
4. Provision of useful, well-designed, properly located space for play, relaxation, and community activities for daytime and evening use in all seasons
5. Provision for grass and trees
6. In communities, improved streets, gutters, walks, and access ways
7. Suitable lighting facilities for streets, walks, and public areas

C. Environmental Control Programs

1. Control sources of air and water pollution and local sources of ionizing radiation
2. Control rodent and insect propagation, pests, domestic animals, and livestock
3. Inspect, educate, and enforce so premises and structures are maintained in such condition and appearance so as not to be a blighting influence on the neighbourhood
4. Community noise control and abatement
5. Building and development regulations

12. A Sampling of Canadian Housing and Sanitation Standards

Compared to the APHA, no official or voluntary health agency in Canada has devoted as much attention through the years to refining housing standards. There do exist, however, various provincial and municipal codes governing the building trades, fire codes, as well as regulations related to housing and sanitation within various provincial public health acts.

12.1 Provincial Public Health Acts

Regulations governing various aspects of housing and sanitation can be found in public health acts in all the provinces. As an example, Manitoba's Public Health Act (RSM 1987 c.P210) has the following regulations:

- 321/88 R. Collection and Disposal of Waste Regulation covering private waste disposal facilities, special types of closets or toilets, and waste disposal ground.
- 322/88 R. Dwellings and Buildings Regulation covering toilets, windows, room dimensions, screens, doors, maintenance of equipment and appliances, cellars and basements, heating.
- 323/88 R. Fumigation and Pest Control Regulation.
- 325/88 R. Insanitary Conditions Regulation dealing specifically with accumulated water and dead animals.
- 330/88 R. Water Supplies Regulation covering water quality, disinfection, wells, and chlorination.
- 331/88 R. Water Works, Sewerage and Sewage Disposal Regulation covering the maintenance of public systems.

12.2 Environmental Health on Indian Reserves

The Indian Act, first legislated in 1874 and last substantially amended in 1952 and in 1985, empowers the Minister of Indian Affairs, under paragraph 73, to make regulations to:

- prevent, mitigate and control the spread of diseases on reserves;
- provide medical treatment and health services for Indians;
- provide compulsory hospitalization and treatment for infectious diseases;
- provide for sanitary conditions... on reserves.

Under the Department of National Health and Welfare Act of 1945, the provision of health services, including environmental sanitation, was transferred from Indian Affairs to the newly reorganized federal health department. Health and Welfare Canada's Medical Services Branch, the agency responsible for health care on most Indian reserves, has established a set of Minimum Requirements for Health in Native Housing (circa 1985). These are:

(1) Water supply: a consistent supply of potable water available from a tap inside the home; also, the provision for heating water must be available
(2) Plumbing: bathtub and/or showers, flush toilet, handwashing sink, kitchen sink
(3) Sewage disposal: all greywater and sewage waste must flow into an approved disposal system
(4) Solid waste disposal: all garbage must be placed in rodent and insect-proof containers and regularly disposed of
(5) Pest control: all exterior windows and doors must be screened
(6) Sanitation: walls and floor must be cleanable and in good repair; kitchen tops must have smooth and water-resistant surface; there should be cold storage for perishable foodstuffs
(7) Overcrowding: the dwelling should be sized and partitioned so that no more than two persons occupy a bedroom and no non-bedroom area is used for sleeping purposes
(8) General structure: free from undue drafts and water leaks
(9) Temperature, humidity and ventilation: minimum temperature 20 degrees Celsius in all rooms, 30-60% humidity
(10) Home safety: separate and child-proof storage area for household chemicals and medicines; open cesspools and lagoons fenced; abandoned freezers and refrigerators should have all latches removed; hot water heaters should have a maximum setting of 60 degrees Celsius.

12.3 Northwest Territories Water and Sanitation Policy

With respect to community infrastructure such as water supply and sanitation, the Northwest Territories Water and Sanitation Policy (1962, cited in McIntyre and Heinke 1987) are potentially applicable to Indian reserves, as least those in the remote areas in the northern parts of the provinces. The policy sets out minimum standards for the type and level of basic services:

(1) Design of water supply and treatment facilities: the Canadian Drinking Water Quality Guidelines will serve as the standard
(2) Minimum basic level of service: a trucked water delivery and sewage pumpout system, supplying potable water of at least 45 litres per capita per day
(3) If a bagged sewage collection system is still in use, there should be collection five times per week, with no more than two consecutive no-service days
(4) Solid waste disposal: the modified landfill method is the minimum acceptable system
(5) The minimum basic level of service is trucked collection once weekly

Based on such criteria, Christensen's evaluation of the state of sanitation in the NWT in 1981 (cited in McIntyre and Heinke 1987) indicated that less than 15 percent of the population received water with unacceptable bacteriological quality, whereas in terms of chemical and aesthetic quality of water, the distribution of water and collection of sewage, the service was unacceptable in only 3-6% of the population. The disposal of sewage and solid waste, however, fared much worse, with 20-40% of the population receiving unacceptable service.

12.4 Rehabilitation of Residential Buildings Program Standards

As Indian reserves are eligible for financial assistance under CMHC's Rehabilitation of Residential Buildings (RRAP), mention should be made of the RRAP Standards (CMHC 1988). These standards are intended for use when determining eligibility for funding. To be eligible, the housing unit must be substandard or deficient and require major repair, or lack basic facilities in one of the following categories:

(1) structural soundness
(2) electrical system
(3) plumbing system
(4) heating system
(5) fire safety
(6) in rural areas - a crowded dwelling

With RRAP funding, all work required to bring the dwelling up to the minimum standard of health and safety described in the publication must be undertaken. Some of the RRAP standards are very detailed and precise, for example, specifications for the floor area of sleeping rooms and closets.

A companion set of standards is CMHC's Minimum Property Standards for Existing Residential Buildings (CMHC 1983) which outlines the minimum requirements where National Housing Act loans are to be made on existing residential buildings. These standards cover the same areas as the RRAP ones but are generally less specific and stringent.

12.5 CMHC's National Occupancy Standards and Consultation Paper

In the Global Agreements on Social Housing signed between the federal and provincial governments in 1986, there are definitions governing various housing indicators:

* crowded dwelling means a dwelling with more than one person per room (excluding bathrooms, halls, pantries and closets and rooms for business purposes);

* inadequate dwelling means a dwelling needing major repairs or lacking basic facilities. Major repairs include defective plumbing, electrical wiring, walls, floors and ceilings. Basic facilities are hot and cold running water, toilet, bathtub or shower;

* suitable dwelling means a dwelling that can accommodate a household according to the following household size/dwelling size relationship [this definition supersedes the previous definition of "crowded dwelling" in an Amending Agreement in 1987]:

(a) a minimum of one, and a maximum of two persons per bedroom
(b) parents are entitled to a bedroom separate from their children
(c) household members age 18 or over are entitled to their own bedroom unless they are married or cohabiting as a spouse
(d) dependents over the age of 5 and of the opposite sex do not share a room

* affordable dwelling means a dwelling for which basic shelter costs are less than 30% of a household's income

In its 1988 Consultation Paper CMHC identifies three conventional dimensions of housing quality:

(1) adequacy: the protection of the health and safety of the occupants;
(2) durability: the protection of health and safety for some minimum period of time;
(3) suitability/livability: the amount and arrangement of space within and around the dwelling.

In addition, housing quality encompasses the environmental context for housing, including such attributes as:

(4) ease of access to employment and services;
(5) the quality of neighbourhood dwellings;
(6) the quality of air and water and absence of noise;
(7) security from crime and risk of loss of property due to fire.

A number of mechanisms exist to foster a minimum quality of housing and the environment. These include the enforcement of building codes, zoning regulations, and the provision of publicly funded and managed infrastructure and services. The continued effort to maintain or improve the quality of housing in the face of even greater urbanization may raise the initial costs, and so restrict low and moderate income households' access to housing. The basic issue is how to achieve the right balance between high quality and reasonable access. The closest this document comes to mentioning the Indian reserve situation is in its acknowledgment that the high prevalence of substandard dwellings in rural areas should be addressed.

13. A Global Perspective on Human Settlements

13.1 The World Health Organization

In the 1960s, housing and health also received considerable attention from the World Health Organization. Various expert groups met and produced recommendations. While not binding on the Member States, standards bearing the imprimatur of the WHO do carry considerable weight. They also view healthful housing as a universal human goal shared by nations in the east and west, north and south. Several technical reports and public health papers were published during this period:

Technical Report No.225: Public Health Aspects of Housing (1961)
Technical Report No.353: Appraisal of the Hygienic Quality of Housing and the Environment (1967)
Public Health Paper No.33: The Physiological Basis of Health Standard for Dwellings (1968)
Technical Report No.544: Uses of Epidemiology in Housing Programs and in Planning Human Settlements (1974)

The 1961 document produced a set of "Fundamentals of a Healthful Residential Environment" (WHO 1961):

(1) A safe and structurally sound, adequately maintained, separate, self-contained dwelling unit for each household, if so desired, with each dwelling-unit providing at least:

a. a sufficient number of rooms, usable floor area and volume of enclosed space to satisfy human requirements for health and for family life consistent with the prevailing

cultural and social pattern of that region, and so used as to avoid overcrowding of living or sleeping rooms;

b. at least a minimum degree of desired privacy, both as between individual persons within the household; and for the members of the household against undue disturbance by external factors;

c. suitable separation of rooms, providing separate bedrooms for adolescent and adult members of opposite sex except husband and wife; and for domestic animals to be housed apart from the living area of the dwelling-unit.

d. a potable and palatable water supply, piped by sanitary plumbing into the dwelling-unit in quantities large enough to provide for all the personal and household uses essential for sanitation, comfort and cleanliness.

e. a safe and sanitary means for the disposal of sewage, garbage and other wastes.

f. sufficient facilities for washing and bathing.

g. appropriate facilities for cooking, dining and the storage of food, household goods and personal belongings.

h. appropriate protection against excess heat, cold, noise and dampness.

i. adequate ventilation and internal air free of toxic or noxious agents.

j. sufficient natural and artificial illumination.

(2) A neighbourhood or micro-district setting for the dwelling which conforms with sound town, country and regional planning practice and consists of:

a. when economically feasible, a community water supply, sewage collection and treatment, collection and disposal of garbage and other wastes, and storm-water drainage.

b. an atmosphere which is free of toxic or noxious gases, odours, fumes, or dusts.

c. protection facilities of police and fire services.

d. industrial, commercial, cultural, social, religious, educational, recreational and health and welfare facilities connected to the residential structures by a network of roads and public transportation and a system of footpaths.

e. freedom from hazards to health, welfare and public morals.

The 1974 document set out "Performance Criteria for Healthful Housing" (WHO 1974):

(1) Healthful housing provides physical protection and shelter to the extent determined by local climatic conditions.

(2) Healthful housing provides adequately for cooking, eating, washing, and excretory functions.

(3) Healthful housing is designed, constructed, maintained, and used in a manner such as to prevent the spread of communicable disease by the respiratory route, by disease vectors harboured in housing and its environment, or by fecal contamination.

(4) Healthful housing provides for protection from hazards of exposure to noise and pollution.

(5) Healthful housing is free from unsafe physical arrangements due to construction or maintenance, and from toxic or harmful materials.

(6) Healthful housing encourages personal and community development, promotes social relationships, reflects a regard for ecological principles, and by these means promotes mental health.

The influence of the APHA principles and standards is evident in these international deliberations. In discussing the use of standards in housing appraisal the 1967 report noted that so-called "performance standards" only state objectives which need to be reduced to specific criteria suitable for measurement by field observation and inspection. Also standards can only represent currently acceptable means of meeting the objectives - they must be periodically re-examined to ensure that they satisfy human needs (WHO 1967).

The 1978 Declaration of Alma Ata, which adopted "Primary Health Care" (PHC) as the central thrust in national health strategies of Member States, considered environmental sanitation as an integral part of PHC. Much of WHO's effort to attain "Health for All by the Year 2000" hinges as much on the improvement in housing, water and sanitation as on simplifying and expanding basic health services in the world's developing countries. The 1980s in fact were declared the UN International Drinking Water Supply and Sanitation Decade.

13.2 United Nations-Habitat

Within the housing sector, the 1976 UN Conference on Human Settlements (Habitat) in Vancouver brought world attention to the growing problems associated with rapid and uncontrolled urbanization in the Third World. Barbara Ward's Home of Man, published on the eve of the conference, synthesized an array of alarming statistics and pleaded for concerted international action (Ward 1976). The UN now has a specialized agency called Commission on Human Settlements, with a Centre for Human Settlements based in Nairobi. Following 1987, the International Year of Shelter for the Homeless, the UN General Assembly adopted Resolution 43/181 in December 1988, launching the "Global Strategy for Shelter to the Year 2000" (United Nations 1990).

The Global Strategy recognizes the universal right to adequate housing, although the extent of governmental obligations would vary from nation to nation. Inadequate and insecure shelter, the Strategy warns, will lead to social and political instability and will hamper economic development. To address this obligation, governments must make fundamental changes in policy by adopting an "enabling" approach. This approach implies that people will be accorded the opportunity to meet their housing requirements according to their own priorities and capacities.

Canada declared its commitment to the Global Strategy. Its delegation to the Commission on Human Settlements had included representatives from CMHC, External Affairs, CIDA, academe, and the Canadian Real Estate Association. In a paper outlining Canada's role, Oberlander and Fallick (1990) recommended the development of specific initiatives to enable the lowest income groups to attain affordable housing "within the context of a market economy but with full support of the federal and provincial governments". Such initiatives would include (1) home ownership - a rent-to-own program; (2) municipal zoning in support of affordable family housing; and 3) upgrading existing public housing and other available government-owned housing stock. There is, however, no mention of rural or Native housing in the Canadian context.

14. Social, Economic and Cultural Dimensions

14.1 Introduction

Although much of Indian housing in Canada is still characterized by dilapidation, overcrowding and unsanitary conditions, it is now increasingly recognized that good health requires more than the remedying of these "traditional" deficiencies. In a review of the biomedical, social science and urban planning literature, Lindheim and Syme (1983) listed three new "risk factors" for poor health. These are (1) lack of meaningful social relationships: the interruption of supportive ties between individuals; (2) low hierarchical positions: low self esteem, lack of control over one's lives, absence of meaningful participation; (3) disconnection from biological and cultural heritage. While writing about North American (or modern) society in general, it is obvious that Canadian Indians suffer inordinately from all three conditions. It is also obvious that, even when the physical aspects of housing such as broken windows, cracked walls, faulty furnaces, leaky roofs, strewn garbage, inadequate water supply and absent indoor plumbing on Indian reserves have been completely remedied - no mean task in itself - there will remain substantial ill-health.

Jacobs and Stevenson (1981) categorized the housing and health literature into three analytical perspectives: the individualistic, the reformist, and the dialectical-materialist. From a Marxist perspective, these authors criticised the first two for ignoring the relation between housing and "mode of production". Other authors have also pointed out the pitfall of studies based on individuals as "free agents", ignoring that they are also members of social groups who differ in the use and control of available household and neighbourhood space because of their position in the social and political system (Gabe and William 1987).

The mere provision of new housing does not necessarily improve the quality of life. Bone and Green (1983) studied the housing assistance program for remote Metis settlements in northern Saskatchewan funded jointly by the federal and provincial governments in the 1960s. In a survey in 1976, the overall quality and size of dwellings had improved. However, the low-income owners spent little money on maintenance, with the result that the physical conditions of their dwellings were worse than provincial government staff houses.

Housing, of course, is more than a physical structure designed to keep its occupants warm, dry, safe, and free from disease. Peoples' homes are also meaningful places, intimately connected to their sense of social and emotional well-being. Moreover, peoples' perceptions of the quality of their housing, in terms of its physical structure, vary tremendously from one cultural group to another. The best example of the importance of these differences would be the varying perception of "crowding" between for example urban Japanese and mid-western Americans.

A discussion of the importance of social, economic and cultural variables in relation to housing and health in Native communities can be considered along the following dimensions:

(1) Architectural and aesthetic qualities of housing which reflect cultural values.
(2) Physical location of houses in communities affecting social interaction patterns.
(3) Issues of home ownership and cost of maintenance in relation to local economic and cultural values.

In each of these areas, housing in Native communities can profoundly affect the psychological and social health of the population. Indeed, in some instances, increases in the frequency of alcohol abuse, family violence and suicide have been linked to particularly problematic housing arrangements. Shkilnyk (1985) for example, describes the social malaise and pathology that erupted when the Grassy Narrows Reserve was moved from its traditional location to a new settlement. Clan-based residence patterns on the old reserve were replaced by a random mixing of families and clans. Social interaction was radically changed, leading to increased friction and tension. Detailed analysis of these issues is provided below.

14.2 Cultural Values Affecting Architectural, Aesthetic Qualities

The maintenance of cultural values related to spirituality, socialization of children, respect for elders, and kinship obligations are important to health promotion. Many studies have demonstrated that in situations of rapid cultural change where value systems are destroyed or fragmented, serious psychological trauma occurs (Berry 1985). Studies have also demonstrated that there is a lower prevalence of psychological and social disorder in communities which are able to maintain traditional values while at the same time participating in the wider social and economic environment (Kruse et at 1982). Often these studies demonstrate that protecting cultural values can be achieved through relatively simple mechanisms such as holding community feasts and ceremonies, and engaging in other traditional activities. Increasingly, Native communities are looking at the physical design of their community buildings such as schools, community halls, and houses as mechanisms for further enhancement of traditional values.

Examples of cultural values related to housing design are:

* spatial orientation of buildings along an east/west axis
* use of medicine wheel symbols and colours in layout of rooms and decor
* rooflines and exteriors modelled after traditional "lodge" structures
* interior designs which facilitate a central open space for social gatherings
* functional design which facilitates certain cultural activities such as the butchering of wild game
* design of sleeping/living areas in accordance with cultural rules about privacy, respect and authority within families.

The siting of housing in a community is also fundamentally affected by cultural values. Aboriginal people do not assess the quality of a potential residential area solely in terms of its physical properties (i.e., drainage properties, foundation soil, etc.). Land is also assessed in terms of its spiritual qualities with certain areas considered unsuitable for human settlement due to the presence of bad spirits (Shkilnyk 1985). Some aboriginal people maintain that if housing is built on bad land, misfortune (ill health) may to plague the inhabitants.

Housing must also be located so as to facilitate traditional economic pursuits. Settlements must be near resources and houses should be close to waterways. Houses built in locations which inhibit the pursuit of hunting and fishing affect health in two ways. Not only may there be a direct negative impact on diet, but family members other than middle-aged males may be less likely to participate in land based activities, thereby affecting the socialization of children and family relations.

14.3 Social Interaction Patterns Affected by Housing Location

As mentioned above, Shkilnyk's (1985) study of the destruction of the Grassy Narrows community indicates that significant social disruption occurred when the band was moved from its traditional location to a new townsite. Problems associated with relocation included:

(1) Clan territoriality disrupted by mixing of families.
(2) Clan or extended family privacy invaded by mixing of families.
(3) Equality of access to river disrupted leading to jealousy and competition.
(4) Open space around houses which was important for the observation of visitors lost leading to suspicion and anxiety.
(5) Communal space important for ceremonial interaction of clans lost contributing to breakdown in clan relations.

The above problems arise from the geographic location of housing units; similar problems can also be created by the size and interior design of houses. When government-assisted housing was first introduced into Native communities, reports were mixed regarding benefits (Thomas and Thompson 1972). Although these authors acknowledged that improved housing was necessary to curb mortality rates from infectious disease, new housing units also resulted in acculturative stress. Family units used to living, working and sleeping in a communal space were forced to adjust to the "privacy" values implicit in houses with separate sleeping areas. In many instances, bedrooms went unused as families continued their traditional pattern of sleeping in a communal bed.

While the impact of Western housing designs on Native culture has largely been accepted and adjustments have been made, concerns are now being raised that the revival and protection of Native family life requires a re-consideration of housing styles and designs. Concerns which could be incorporated into housing designs include:

(1) Care of the elderly person within the extended family unit. Current housing designs tend to promote the social isolation of elderly people.
(2) Accommodation of large family units and particularly young adult children (married and unmarried). Given the sometimes vast cultural differences which can exist within families, it is important to both provide for the privacy of different generations while at the same time ensuring that Native values, related to authority within families is maintained.
(3) Inter-generational conflicts inhibited through designs which maintain integrity of extended family unit but which provide for privacy and recreation to different generations who may have distinct cultural needs.

14.4 Local Economic Factors Affecting Home Ownership and Maintenance

Aside from the direct health impacts of too little housing in poor physical repair (e.g., overcrowding, house fires), the issue of home ownership and maintenance is also related to social and emotional well-being. Cross-cultural research has indicated that the family home is generally a fundamental component of an individual's sense of security, confidence and self-esteem. Individual and family identity is often linked significantly to the physical structure in which they reside (i.e., use of symbols and decor to represent family traditions, etc.). Housing quality is also linked to perceptions of status and authority in community life; factors which may have an impact on mental health. Lindheim and Syme (1983) support the importance of these issues in their review cited above.

As earlier sections of this document attest, Native housing in Canada has been provided largely through government subsidy with tenant rents maintained at levels consistent with the socioeconomic status of the family. Maintenance and renovation have generally not been the responsibility of occupants but rather of Band and other federal government agencies. The impact of these policies has apparently been to decrease perceptions of prideful ownership and maintenance, sometimes resulting in a deterioration of housing quality.

However, several considerations are relevant to this issue. First of all, and despite the historical changes that have occurred in aboriginal settlement patterns, most Native cultures in Canada were historically nomadic. In many instances, living sites would be abandoned and new ones built when the family group or community moved. In other instances, housing would be dismantled, transported and reconstructed in new environments. In both cases, cultural values relating to maintenance of both the housing unit and the surrounding environment would likely conflict with a value orientation necessary for the on-going maintenance of permanent housing. The extent to which traditional values are persistent in the face of modernization and generational change is of course a subject of much scientific and public debate. However, most commentators from both sectors would agree that "tradition", however defined, continues to play a role in contemporary understandings, although they would likely disagree about the relative importance.

Other considerations pertaining to the discussion of sociocultural factors related to home ownership and maintenance include the issue of individual versus collective responsibility for community maintenance in aboriginal settlements. While a general discussion of this issue is extremely complicated and beyond the scope of the present review, recent evidence suggests that have maintenance and renovation improves when aboriginal communities maintain a collective responsibility for individual homes. Communities which have collectively addressed alcohol and family violence issues (e.g. Alkali Lake in British Columbia) have collectively used home improvements as a way of signalling their support to Band members undergoing alcohol treatment and therapy.

In other situations such as the Northwest Territories, pride of ownership and improvements in housing maintenance seem to be associated with several developments. First of all, housing quality has improved substantially in recent years. Families assuming residence in new housing unit often indicate a more "permanent" sense of residence rather than the transient attitude that characterized attitudes towards housing in the sixties and seventies. Maintaining a house when one envisions raising a family and growing old in the unit is more likely to be associated with a heightened understanding of the importance of maintenance and repair than if the housing unit is perceived as temporary shelter until a better unit becomes available. This attitude is also likely to be independent of whether a person is renting the unit or paying off a mortgage.

The Northwest Territories has also implemented a program of home ownership where sweat equity is provided by the occupant during the construction phase. Long term maintenance is also the responsibility of the occupant. Although this system is likely contributing to the long-term maintenance of improved housing stock, there is also some evidence that it is also contributing to the emergence of a multi-tiered structure of access to quality housing in aboriginal communities.

Further investigation into the above issues and their relationship to mental health is clearly required if housing policy for aboriginal communities is to be healthful. To a great extent, the above discussion is based on the field experience of the author(s) and needs to be systematically investigated in order to support or refute some of the themes described. This preliminary discussion is included however to alert the reader to significant areas of concern that may not be fully developed in the literature, but nonetheless should be recognized as important issues for policy development.

PART FIVE SUMMARY AND CONCLUSIONS

1. There is a large international literature on the health effects of the housing environment and community infrastructure. The available evidence is often conflicting and inconsistent and not all of it is relevant or applicable to Canadian Indian reserves.

2. Extensive data are available on the adequacy and quality of housing and community infrastructure on Canadian Indian reserves. Despite impressive improvements and massive government subsidies, there still exists a large gap between the situation on Indian reserves and the larger Canadian community today.

3. Similarly, a variety of health indicators also point to the discrepancy in health status between aboriginal Canadians and Canadians nationally. While the role of infectious diseases in mortality and morbidity has declined substantially, chronic, non-communicable diseases and injuries and violence have assumed increasing importance.

4. While it is plausible that the poor health status of Canadian Indians can be attributed to the substandard housing and environmental conditions, only a few regional case studies have been conducted in Canadian aboriginal communities to establish the causal link. Such studies are faced with formidable methodological obstacles such as the small community size, the absence of adequate "exposure" data, and the difficulty in choosing an appropriate "outcome" measure. Many factors besides housing, water supply and sanitation are determinants of health, including socioeconomic status, accessibility to health services, nutritional status, social stress, etc. An independent role for housing and infrastructure cannot always be demonstrated.

5. While housing deficiencies on Indian reserves affect all sectors of the population, the elderly and physically disabled are particularly vulnerable. Few programs exist to serve their special needs. It can be expected that demographic trends towards an increasingly aged population will occur and aggravate the housing and health care needs.

6. A variety of interventional and observational studies from around the world have generally demonstrated some beneficial health effects of improvements in water and sanitation. The state of the scientific evidence, particularly with regard to the independent effects and relative importance of water quantity, water quality, waste disposal, personal hygiene, and medical interventions, is less critical in the Canadian policy context. The social and political imperative in Canada to redress inequity between Indian reserves and the rest of the population rules out "selective" primary health care as a policy option. This is not to say that existing resources directed at reserves should not be more efficiently employed. Furthermore, in aiming for a level of housing and infrastructure comparable to that of non-Native Canadians, due consideration must be paid to the unique social, cultural and ecological factors existing on Indian reserves.

7. It should be noted that the traditional health problems attributed to poor housing, water and sanitation - such as intestinal, respiratory and skin infections - are not the major causes of mortality among Canadian Indians today, although they do contribute to substantial morbidity and health care utilization. The most serious health problems are injuries resulting from accidents and violence. To reduce the incidence of these problems, attention to predisposing factors related to the host, agent, the physical and social environment in the home and community is required. Strategies should not be restricted

to individual-based health and safety education, but also to broader measures such as modifying the design of hazardous products and environments and improving overall socio-economic conditions in the community.

8. While Canadian Indian reserves are still at a stage where basic deficiencies in housing remain to be remedied, in the rest of the population, new hazards relating to air and water contamination by chemical and physical agents are increasingly being recognized. Data relating to indoor air quality on Indian reserves are not readily available, although based on knowledge of the extensive use of woodstoves in many rural and remote reserves and the high prevalence of cigarette smoking, the potential for serious indoor air pollution exists. As to the other categories of indoor pollutants, it is possible that the situation in Indian reserve homes is not substantially different from the average Canadian home. There is an urgent need to monitor this emerging health hazard.

9. A variety of housing standards from both Canada and abroad were reviewed in this monograph. There is indeed extensive overlap among these, probably reflecting the intellectual influence of the seminal work on the principles of healthful housing by the American Public Health Association in the 1930s. There is no reason to suggest that Canadian Indian reserves should have housing standards that depart from national and international norms. Indian reserves should adhere to provincial regulations relating to environmental health. Such regulations, of course, need to be adapted to the special circumstances on reserves, particularly those in rural and remote areas. As a short and practical checklist, the Minimum Requirements for Health in Native Housing used by Medical Services Branch of Health and Welfare Canada are adequate. The utility of more refined and detailed specifications is difficult to establish and justify.

Alphabetical Listing of Journals/Periodicals Cited

Abbreviation	Title
Alaska Med	Alaska Medicine
Allergy	Allergy
Am Indian J	American Indian Journal
Am J Clin Nutr	American Journal of Clinical Nutrition
Am J Dis Child	American Journal of Diseases of Children
Am J Epidemiol	American Journal of Epidemiology
Am J Psychiatry	American Journal of Psychiatry
Am J Public Health	American Journal of Public Health
Am J Trop Med Hyg	American Journal of Tropical Medicine Hygiene
Am Sociol Rev	American Sociological Review
Am Water Works Assoc J	American Water Works Association Journal
Ann NY Acad Sci	Annals of the New York Academy of Sciences
Ann Trop Med Parasitol	Annals of Tropical Medicine and Parasitology
Annu Rev Public Health	Annual Review of Public Health
Arctic Anthropol	Arctic Anthropology
Br J Cancer	British Journal of Cancer
Br J Prev Soc Med	British Journal of Preventive and Social Medicine
Br Med J	British Medical Journal
Bull WHO	Bulletin of the World Health Organization
Can Fam Physician	Canadian Family Physician
Can J Aging	Canadian Journal of Aging
Can J Civil Engineer	Canadian Journal of Civil Engineering
Can J Public Health	Canadian Journal of Public Health
Can Med Assoc J	Canadian Medical Association Journal
Can Public Policy	Canadian Public Policy
Can Rev Sociol Anthropol	Canadian Review of Sociology and Anthropology
Can Stud Pop	Canadian Studies in Population
Community Med	Community Medicine
Dan Med Bull	Danish Medical Bulletin
Demography	Demography
Environ Health Perspect	Environmental Health Perspectives
Environ Res	Environmental Research
Epidemiol Rev	Epidemiologic Reviews
Health Reports	Health Reports
Health Services Rep	Health Services Reports
Hum Ecol	Human Ecology
Int J Dermatol	International Journal of Dermatology
Int J Epidemiol	International Journal of Epidemiology
Int J Health Serv	International Journal of Health Services
J Air Pollution Control	Journal of the Air Pollution Control Association
J Chron Dis	Journal of Chronic Diseases
J Epidemiol Community	Journal of Epidemiology and Community Health
J Health Hum Behav	Journal of Health and Human Behaviour
J Health Soc Behav	Journal of Health and Social Behaviour
J Housing	Journal of Housing
J Hyg	Journal of Hygiene
J Infect Dis	Journal of Infectious Diseases
J Sch Health	Journal of School Health
J Trauma	Journal of Trauma
JAMA	Journal of the American Medical Association
Meddelelser om Gronland	Meddelelser om Gronland: Health and Society
N Engl J Med	New England Journal of Medicine
Northern Engineer	Northern Engineer
Pediatrics	Pediatrics
Proc Roy Soc Med	Proceedings of the Royal Society of Medicine
Public Health Rep	Public Health Reports
S Afr Med J	South African Medical Journal
Scand J Respir Dis	Scandinavian Journal of Respiratory Diseases
Scand J Soc Med	Scandinavian Journal of Social Medicine
Soc Sci Med	Social Science and Medicine
Thorax	Thorax
Urban Studies	Urban Studies
West J Med	Western Journal of Medicine

BIBLIOGRAPHY

Aaby P, Bukh J, Lisse IM, Smits AJ. Overcrowding and intensive exposure as determinants of measles mortality. Am J Epidemiol 1984;120:49-63.

Adams FJ. Housing and health: the planned community. Am J Public Health 1949;39:467-70.

APHA Program Area Committee on Housing and Health. Basic health principles of housing and its environment. Am J Public Health 1969;59:841-43.

Azurin JC, Alvero M. Field evaluation of environmental sanitation measures against cholera. Bull WHO 1974;51:19-26.

Barker DJ, Coggon D, Osmond C, Wickham C. Poor housing in childhood and high rates of stomach cancer in England and Wales. Br J Cancer 1990;61:575-8.

Barrow MV, Niswander JD, Fortuine R, eds. Health and Disease of American Indians North of Mexico: A Bibliography, 1800-1969. Gainesville, FA: University of Florida Press; 1972.

Beauvais JE. Health Status on Canadian Indian Reserves 1971-1984 [Dissertation]. Montreal: McGill University, 1988.

Berg O, Adler-Nissen J. Housing and sickness in South Greenland: a sociomedical investigation. In: Shephard RJ, Itoh I, editors. Circumpolar Health: Proceedings of the Third International Symposium, Yellowknife, NWT. Toronto: University of Toronto Press; 1976:627-35.

Berry J. Acculturation Among Circumpolar Peoples: Implications for Health Status. Arctic Medical Research 1985;40:21-7

Bersh D, Osorio MM. Studies of diarrhoea in Quindio (Colombia): problem related to water treatment. Soc Sci Med 1985;21:31- 9.

Bierman TJ, Croke KG, Swartzman D. Accuracy and precision of home radon monitoring and the effectiveness of EPA monitoring guidelines. J Air Pollution Control Assoc 1989;39:953-9.

Bjerregaard P. Housing standards, social group, and respiratory infections in children of Upernavik, Greenland. Scand J Soc Med 1983;11:107-11.

Bjerregaard P, Bjerregaard B. Disease pattern in Upernavik in relation to housing conditions and social group. Meddelelser om Gronland: Man and Society 1985;(8):3-18.

Blum BM, Elkin WF. The relation of housing to the incidence of meningococci disease in an outbreak in Oak Ridge, Tenn. Am J Public Health 1949;39:1571-77.

Blum D, Feachem RG. Measuring the impact of water supply and sanitation investments on diarrhoeal diseases: problems of methodology. Int J Epidemiol 1983;12:357-65.

Blumenthal DS, Taplin D, Schultz MG. A community outbreak of scabies. Am J Epidemiol 1976;104:667-72.

Bone RM, Green MB. Housing assistance and maintenance for the Metis in Northern Saskatchewan. Can Public Policy 1983;9: 476-86.

Booth A, Cowell J. Crowding and health. J Health Soc Behav 1976; 17:204-20.

Boyd WL, Boyd JW. Water supply and sewage disposal developments in the Far North. Am Water Works Assoc J 1965;57:858-68.

Brennan ME, Lancashire R. Association of childhood mortality with housing status and unemployment. J Epidemiol Community Health 1978;32:28-33.

Briscoe J. Water supply and health in developing countries: selective primary health care revisited. Am J Public Health 1984;74:1009-13.

Britten RH. Illness and accidents among persons living under different housing conditions. Public Health Rep 1941;56:609- 40.

Britten RH. New light on the relation of housing to health. Am J Public Health 1942;32:193-9.

Brocklehurst C. The Effect of Water Supply and Sanitation on Health on Indian Reserves in Manitoba [Dissertation]. Toronto: University of Toronto, Department of Civil Engineering, 1985.

Brooke MM, Healy GR, Levy P et al. A sample survey of selected areas in and near Little Rock, Arkansas to assess the prevalence of Entameba histolytica. Bull WHO 1963;29:813-22.

Bruce L. A Geographical Approach to Indian Health Care: Modelling Patterns of Hospital Use in Manitoba [Dissertation]. Winnipeg: University of Manitoba, 1991.

Butz WP, Habicht JP, DaVanzo J. Environmental factors in the relationship between breastfeeding and infant mortality: the role of sanitation and water in Malaysia. Am J Epidemiol 1984;119:516-25.

Cairncross S, Carruthers I, Curtis D et al. Evaluation of Village Water Supply Planning. New York: John Wiley and Sons; 1980.

Campbell M. Appropriate Water and Sanitation Technologies for Indian Communities in Northern Ontario. Toronto: Pollution Probe; 1980. Report prepared for the Royal Commission on the Northern Environment.

Canada Mortgage and Housing Corporation. A Consultation Paper on Housing Quality. Ottawa: CMHC; 1988.

Canada Mortgage and Housing Corporation. National Housing Act: Minimum Property Standards for Existing Residential Buildings. Ottawa: CMHC; 1986.

Canada Mortgage and Housing Corporation. Standards for the Rehabilitation of Residential Buildings. Ottawa: CMHC; 1988.

Canadian Housing Information Center. Bibliography on Native Housing. Ottawa: Canada Mortgage and Housing Corporation; 1988.

Chapin FS. Some housing factors related to mental hygiene. Am J Public Health 1951;41:839-45.

Church RE, Knoweldon J. Scabies in Sheffield: a family infestation. Br Med J 1978;1:761-3.

Clatworthy S, Stevens H. An Overview of the Housing Conditions of Registered Indians in Canada. Ottawa: Department of Indian Affairs and Northern Development; 1987.

Coetzee N, Yach D, Joubert G. Crowding and alcohol abuse as risk factors for tuberculosis in the Mamre population: results of a case-control study. S Afr Med J 1988;74:352-4.

Cohen MA, Ryan PB, Yanagisawa U, Spengler JD. Indoor/outdoor measurements of volatile organic compounds in the Kanawha Valley of West Virginia. J Air Pollution Control Assoc 1989; 39:1086-93.

Collins JJ, Kasap HS, Holland WW. Environmental factors in child mortality in England and Wales. Am J Epidemiol 1971;93:10- 22.

Collishaw NE, Kirkbride J, Wigle D. Tobacco smoke in the workplace: an occupational health hazard. Can Med Assoc J 1984;131:1199-204.

Committee on Environmental Hazards. Policy statement: Pediatric problems related to deteriorated housing. Pediatrics 1972; 49:627.

Dennis CA, Pearson BL. The Effects of the Living Environment on the Health of Saskatchewan Indians. Regina, SK: Prairie Institute of Environmental Health; 1978. (PIEH Pub.No.12).

Department of Indian Affairs and Northern Development. Fire Loss Report - 1989. Ottawa: Technical Services, DIAND; 1990.

Department of Indian Affairs and Northern Development. Impacts of the 1985 Amendments to the Indian Act (Bill C-31): Summary Report. Ottawa: DIAND; 1990.

Department of Indian Affairs and Northern Development. Indian Reserve Community Profiles, Manitoba Region 1988. Ottawa: Department of Indian Affairs and Northern Development; 1989.

Department of Indian Affairs and Northern Development. Laying the Foundation of a New On-Reserve Housing Program. Ottawa: DIAND; 1990.

Department of Indian Affairs and Northern Development. Statistical Report: Listing of Information Related to the Housing Needs Analysis - 1977. Ottawa: Program Support Group, Indian and Inuit Affairs, DIAND; 1977.

Department of National Health and Welfare and Department of Northern Affairs and National Resources. Eskimo Mortality and Housing. Ottawa: DNHW and DNANR; 1960.

Department of National Health and Welfare. Health Indicators Derived from Vital Statistics for Status Indian and Canadian Populations. Ottawa: DNHW, Medical Services Branch; 1988.

Department of National Health and Welfare. Health Status of Canadian Indians and Inuit: update 1987. Ottawa: DNHW, Medical Services Branch; 1988.

Douglas RG,Jr, Lindgram KM, Cough RB. Exposure to cold environment and rhinovirus cold: failure to demonstrate an effect. N Engl J Med 1968;279:742-7.

Duvall D, Booth A. The housing environment and women's health. J Health Soc Behav 1978;19:410-7.

Duxbury L. The Relative Effects of Community Characteristics and Health Care Facilities in the Sioux Lookout Zone [Dissertation]. Waterloo, ON: University of Waterloo, Faculty of Management, 1983.

Ekos Research Associates. Summary Report: Evaluation of the On Reserve Housing Program. Ottawa: Ekos Research Associates; 1985.

Elton PJ, Packer JM. A prospective randomised trial of the values of rehousing on the grounds of mental ill-health. J Chron Dis 1986;39:221-7.

Enarson DA, Grzybowski S. Incidence of active tuberculosis in the Native population of Canada. Can Med Assoc J 1986;134:1149- 52.

Engleberg NC, Holburt EN, Barrett TJ et al. Epidemiology of diarrhoea due to rotavirus on an Indian reservation: risk factors in the home environment. J Infect Dis 1982;145:894- 8.

Esrey SA, Habicht J-P. Epidemiologic evidence for health benefits from improved water and sanitation in developing countries. Epidemiol Rev 1986;8:117-128.

Evers SE, Rand CG. Morbidity in Canadian Indian and non-Indian children in the first year of life. Can Med Assoc J 1982; 126:249-52.

Evers SE, Rand CG. Morbidity in Canadian Indian and non-Indian children in the second year of life. Can J Public Health 1983;74:191-4.

Eyles DE, Jones FE, Smith CS. A study of Entameba histolytica and other intestinal parasites in a rural West Tennessee community. Am J Trop Med Hyg 1953;2:173-90.

Farr LE. Medical consequences of environmental home noise. JAMA 1967;202:171-4.

Feachem RG, Bradley DJ, Garelick H, Mara DD. Appropriate Technology for Water Supply and Sanitation: Health Aspects of Excreta and Sullage Management - A State-of-the-Art Review. Washington, DC: The World Bank; 1981.

Federal-Provincial Advisory Committee on Environmental and Occupational Health. Exposure Guidelines for Residential Indoor Air Quality. Ottawa: Health and Welfare Canada; 1987.

Federal-Provincial Working Group on Drinking Water. Guidelines for Canadian Drinking Water Quality. Ottawa: Health and Welfare Canada; 1978.

Friesen B. Haddon's strategy for prevention: application to Native house fires. In: Fortuine R, editor. Circumpolar Health 84. Seattle: University of Washington Press; 1985: 105-9.

Gabe J, Williams P. Women, housing, and mental health. Int J Health Serv 1987;17:667-9.

Galloway A. The Smoke-free Guide: How to Eliminate Tobacco Smoke from Your Environment. Victoria, BC: Qualy Publishing; 1986.

Gamble DJ, Janssen CT. Evaluating alternative levels of water and sanitation services for communities in the Northwest Territories. Can J Civil Engineer 1974;1:116-28.

Gardner G, Frank AL, Taber L. Effects of social and family factors on viral respiratory infection and illness in the first year of life. J Epidemiol Community Health 1984;38:42- 8.

Gelperin A. Relationship of housing to incidence of upper respiratory infection in New Haven grade school children. J Sch Health 1950;:290-2.

Gerein HJ. Community Planning and Development in Canada's Northwest Territories. Yellowknife, NT: Government of the Northwest Territories and Department of Indian and Northern Affairs; 1980.

Ghipponi P, Darrigol J, Skilova R, Cvjetanovic B. Study of bacterial air pollution in an arid region of Africa affected by cerebrospinal meningitis. Bull WHO 1971;45:95-101.

Gibson MJ. The prevention of falls in later life. Dan Med Bull 1987;34(Suppl 4):1-24.

Gillies I. A Framework for Improving Water Services in Manitoba's Remote Communities [Dissertation]. Winnipeg: University of Manitoba, 1975.

Ginsberg K. An Investigation of the Relationship Between Health and Development in Northern Manitoba [Dissertation]. Winnipeg: University of Manitoba, 1980.

Goodwin MH, Love GJ, Macket DC, Wanner RG. Observations of familial occurrence of diarrhoea and enteric pathogens. Am J Epidemiol 1966;84:268-81.

Gordon JE, Behar M, Scrimshaw NS et al. Acute diarrhoeal disease in less developed countries. Bull WHO 1964;31:1-28.

Gorosomov M. Physiological Basis of Health Standards for Dwellings. Geneva: World Health Organization; 1968. (Public Health Papers No.33).

Graham NM. The epidemiology of acute respiratory infections in children and adults: a global perspective. Epidemiol Rev 1990;12:149-78.

Green MS. Epidemiology of scabies. Epidemiol Rev 1989;11:126-50.

Gremliza FG. A method for measuring the quality of village conditions in less developed rural areas. Am J Public Health 1965;55:107-15.

Griffin WV, Mauvitzen JH, Kasmer JV. The psychological aspects of the architectural environment: a review. Am J Psychiatry 1959;125:1057-62.

Grisham JW, ed. Health Aspects of the Disposal of Waste Chemicals: A Report of the Executive Scientific Panel. New York: Pergamon Press; 1986.

Guerrant RL, Kirchhoff LV, Shields DS. Prospective study of diarrhoeal illnesses in northeastern Brazil: patterns of disease, nutritional impact, etiologies, and risk factors. J Infect Dis 1983;148:986-7.

Gulati PV, Singh KP, Braganza C. Role of sociocultural and environmental factors in the cause of scabies. Int J Dermatol 1977;16:281-3.

Haddon W, Jr. Advances in the epidemiology of injuries as a basis for public policy. Am J Epidemiol 1980;95:411-21.

Haddon W, Jr. Energy damage and the ten countermeasure strategies. J Trauma 1973;13:321-31.

Haddon W, Jr. A note concerning accident theory and research with special reference to motor vehicle accidents. Ann NY Acad Sci 1963;107:635-46.

Hamby C, Beach DA, Pinder N. Snowmobile injuries in northern Newfoundland and Labrador, 1985-86 winter season. In: Linderholm H, Backman C, Broadbent N, Joelsson I, editors. Circumpolar Health 87: Proceedings of the 7th International Congress on Circumpolar Health. Oulu, Finland: Nordic Council for Arctic Medical Research; 1988:406-8.

Hebert JR. Effects of water quality and water quantity on nutritional status: findings from a south Indian community. Bull WHO 1985;63:143-55.

Heinke GW. Municipal services. In: Gerein HJ. Community Planning and Development in Canada's Northwest Territories. Yellowknife, NT: Government of the Northwest Territories and the Department of Indian and Northern Affairs; 1980:143-157.

Hislop TG, Threlfall WJ, Gallagher RP, Band PR. Accidental and intentional violent deaths among British Columbia Native Indians. Can J Public Health 1987;78:271-4.

Hobart CW. Socioeconomic correlates of mortality and morbidity among Inuit infants. Arctic Anthropol 1975;12(1):37-48.

Hollister AC, Beck MD, Gittelsohn AM, Hemphill EC. Influence of water availability on Shigella prevalence in children of farm labour families. Am J Public Health 1955;45:354-62.

Holma B, Kjaer G. Alcohol, housing and smoking in relation to respiratory disease. Environ Res 1980;21:126-42.

Hosein HR, Corey P, Robertson JD. The effect of domestic factors on respiratory symptoms and FEV1. Int J Epidemiol 1989;18: 390-6.

Huebert EJ. The functioning of environmental health delivery systems in remote northern Manitoba communities [Dissertation]. Winnipeg: University of Manitoba, 1982.

Hyndman SJ. Housing dampness and health amongst British Bengalis in East London. Soc Sci Med 1990;30:131-41.

Interministerial Committee on Indoor Air Quality. Report. Toronto: Ministry of Labour; 1988.

Jackson T, McGarry MG, Rybczynski W, Whyte AV, Zimmerman AP. Users Making Choices:First Technical Report of the Big Trout Lake Sewage System Environmental Assessment. Toronto:
International Council for Adult Education; 1979.

Jacobs M, Stevenson G. Health and housing: a historical examination of alternative perspectives. Int J Health Serv 1981;11:105-22.

Janerich DT, Thompson D, Varela LR et al. Lung cancer and exposure to tobacco smoke in the household. N Engl J Med 1990;323:632-6.

Jarvis GK, Boldt M. Death styles among Canada's Indians. Soc Sci Med 1982;16:1345-52.

Justice JW, comp. Bibliography of Health and Disease in North American Indians, Eskimos and Aleuts: 1969 to 1979. Tucson, AZ: University of Arizona, Native American Research and Training Center; 1987.

Kawata K. Water and other environmental interventions - the minimum investment concept. Am J Clin Nutr 1978;31:2114-23.

Kennedy, Smith Associates. Housing Study: Isolated Communities and Indian Reserves, Prairie Provinces. Winnipeg: Kennedy, Smith Associates; 1967.

Koerte A. Toward the Design of Shelter Forms in the North. Phase I: Native Shelter Forms. Winnipeg: Centre for Settlement Studies, University of Manitoba; 1974. (Series 2:Research Report No.20).

Koopman JS. Diarrhoea and school toilet hygiene in Cali, Colombia. Am J Epidemiol 1978;107:412-20.

Kourany M, Vasquez MA. Housing and certain socioenvironmental factors and prevalence of enteropathogenic bacteria among infants with diarrhoeal disease in Panama. Am J Trop Med Hyg 1969;18:936-41.

Kruse JA, Kleinfeld J. and Travis R. Energy Development on Alaskas' North Slope: Effects on Inupiat Population. Human Organiztion 1982;41:17-106.

Kunitz SJ, Temkin-Greener H, Broudy D, Maffner M. Determinants of hospital utilization and surgery on the Navajo Indian reservation, 1972-1978. Soc Sci Med 1981;15B:71-9.

Leeder S, Corkhill R, Irwig LM, et al. Influence of family factors on the incidence of lower respiratory illness during the first year of life. Br J Prev Soc Med 1976;30:203-12.

Lefebvre GW. The Social and Physical Health Effects of Public Housing on Indian Reservation Families [Dissertation]. Winnipeg: University of Manitoba, 1968.

Lindheim R, Syme L. Environments, people and health. Annu Rev Public Health 1983;4:335-359.

Lithwick NH, Schiff M, Vernon E. An Overview of Registered Indian Conditions in Canada. Ottawa: Department of Indian Affairs and Northern Development; 1986.

Longstaffe S, Postl B, Kao H, Nicolle L, Ferguson CA. Rheumatic fever in native children in Manitoba. Can Med Assoc J 1982; 127:497-8.

Loring WC. Residential environment: nexus of personal interactions and healthful development. J Health Hum Behav 1966;5:166-9.

Lowry S. Housing for people with special needs. Br Med J 1990; 300:321-3.

Lowry S. Indoor air quality. Br Med J 1989;299:1388-90.

Lowry S. Noise, space and light. Br Med J 1989;299:1439-42.

Lowry S. Sanitation. Br Med J 1990;300:177-9.

Lowry S. Temperature and humidity. Br Med J 1989;299:1326-8.

Mackie TT, Mackie JW, Vaughan CM et al. Intestinal parasitic infections in Forsyth County, N. Carolina. IV: Domestic environmental sanitation and the prevalence of Entameba histolytica. Am J Trop Med Hyg 1956;5:29-39.

MacWilliams L, Mao Y, Nicholls E, Wigle D. Fatal accidental childhood injuries in Canada. Can J Public Health 1987;78: 129-35.

Mao Y, Morrison H, Semenciw R, Wigle D. Mortality on Canadian Indian reserves 1976-1983. Can J Public Health 1986;77:263- 8.

Martin AE. Environment, housing and health. Urban Studies 1967;4: 1-20.

Martin AE, Kaloyanova F, Maziarka S, eds. Housing, the Housing Environment, and Health: An Annotated Bibliography. Geneva: World Health Organization; 1976.

Martin CJ, Platt SD, Hunt SM. Housing conditions and ill health. Br Med J 1987;294:1125-7.

Martin TR, Bracken M. Association of low birth weight with passive smoke exposure in pregnancy. Am J Epidemiol 1986; 124:633-42.

McCabe LJ, Haines TW. Diarrhoeal disease control by improved human excreta disposal. Public Health Rep 1957;72:921-8.

McCarthy P, Byrne D, Harrison S, Keithley J. Respiratory conditions: effect of housing and other factors. J Epidemiol Community Health 1985;39:15-9.

McGarry MG, Jackson T, Rybczynski AV et al. Appropriate technologies for water supplies and sanitation in northern communities. Northern Engineer 1980;11(1):4-10.

McGlashan ND. Sudden infant deaths in Tasmania, 1980-86: 7-year prospective study. Soc Sci Med 1989;29:1015-26.

McIntyre L, Heinke G. Health services and water and sanitation services in the Northwest Territories: an examination of the present state of development and some thoughts for the future. Can J Public Health 1987;78:244-8.

McMillan JS. Examination of the association between housing conditions and pulmonary tuberculosis in Glasgow. Br J Prev Soc Med 1957;11:142-51.

Meiklejohn C, Rokala DA, comp. The Native Peoples of Canada: An Annotated Bibliography of Population Biology, Health and Illness. Ottawa: National Museums of Canada; 1986. (Canadian Museum of Civilisation Mercury Series No.134).

Melia RJ, Florey C, Morris RW et al. Childhood respiratory illness and the home environment II: association between respiratory illness and nitrogen dioxide, temperature and relative humidity. Int J Epidemiol 1982;11:164-9.

Menon S, Santosham M, Reid R et al. Rotavirus diarrhoea in APache children: a case-control study. Int J Epidemiol 1990;19:715- 21.

Michael MP. Effects of Municipal Services and Housing on Public Health in the Northwest Territories [Dissertation]. Toronto: University of Toronto, 1984.

Millar WJ. Mortality patterns in a Canadian Indian population. Can Stud Pop 1982;9:17-31.

Miller DW. Geohydrological surveys at chemical disposal sites. In: Assessment of Health Effects at Chemical Disposal Sites: Proceedings of a Symposim. June 1981.

Mills CP. Effective management puts an Indian housing authority on the road to sound practices. J Housing 1979;36:310-11.

Mitchell RE. Cultural and health influences on building, housing, and community standards: cost implications for the human habitat. Hum Ecol 1976;4:297-330.

Mitchell RE. Some social implications of high density housing. Am Sociol Rev 1971;36:18-29.

Monto AS, Ross HW. Acute respiratory illness in the community: effect of family composition, smoking and chronic symptoms. Br J Prev Soc Med 1977;31:101-8.

Moore HA, De la Cruz E, Vargas-Mendex O. Diarrhoeal disease studies in Costa Rica, IV: The influence of sanitation upon the prevalence of intestinal infection and diarrhoeal disease. Am J Epidemiol 1966;82:162-84.

Morris K, Morganlander M, Coulehan JL et al. Wood-burning stoves and lower respiratory tract infection in American Indian children. Am J Dis Child 1990;144:105-8.

Morrison HI, Semenciw RM, Mao Y, Wigle D. Infant mortality on Canadian Indian reserves 1976-1983. Can J Public Health 1986;77:269-73.

Myers RL. A survey of indoor air quality in twenty-nine Anchorage residences. Alaska Med 1989;31:103-7.

National Research Council, Committee on Passive Smoking. Environmental Tobacco Smoke: Measuring Exposures and Assessing Health Effects. Washington, DC: National Academy Press; 1986.

Nicholls ES, Davies JW. Accidents, Poisoning and Violence in Canada: An Overview. Ottawa: Health and Welfare Canada; 1980.

Oberlander HP, Fallick AL. Habitat: Canada's International Role in Human Settlements Development. Ottawa: Canada Mortgage and Housing Corporation; 1990.

Ormiston G. Management innovations for Indian housing. J Housing 1977;34:293-5.

Patel M. Effects of the health service and environmental factors on infant mortality: the case of Sri Lanka. J Epidemiol Community Health 1980;34:76-82.

Petreas M, Liu KS, Chang BH et al. A survey of nitrogen dioxide levels measured inside mobile homes. J Air Pollution Control Assoc 1988;38:647-51.

Pierson WE, Koenig JQ, Bardana EJ. Potential adverse health effects of wood smoke. West J Med 1989;151:339-42.

Platt SD, Martin CJ, Hunt SM, Lewis CW. Damp housing, mould growth and symptomatic health state. Br Med J 1989;298:1673- 8.

Pond MA. Housing and health: sanitary aspects of the dwelling. Am J Public Health 1949;39:454-8.

Postl BD, Moffatt ME, Black GB, Cameron CB. Injuries and deaths associated with off-road recreational vehicles among children in Manitoba. Can Med Assoc J 1987;137:297-300.

Pritchard D, Fleisher M. An Examination of Water Quality, Water- Related Health Problems and Water Service Infrastructure in DIAND's Manitoba Northland Communities. Winnipeg: Department of Indian Affairs and Northern Development; 1977.

Puskin JS, Nelson C. EPA's perspective on risks from residential radon exposure. J Air Pollution Control Assoc 1989;39:915- 20.

Quinn RW, Watkins JH, Quinn JP. Rheumatic heart disease and crowding: a survey of rural and urban Connecticut school children. Am J Public Health 1948;38:1071-81.

Rahim MA. Indian Housing Survey 1975. Ottawa: Department of Indian Affairs and Northern Development; 1976.

Rahman M, Rahaman MM, Wojtyniak B, Aziz KM. Impact of environmental sanitation and crowding on infant mortality in rural Bengladesh. Lancet 1985;ii:28-30.

Rasmussen FV, Borchsenius L, Winslow JP, Ostergaard ER. Associations between housing conditions, smoking habits and ventilatory function in men with clean jobs. Scand J Respir Dis 1978;59:264-76.

Richter ED, Jackson S, Peeples S, Wood C, Volante R. Housing and health - a new approach. Am J Public Health 1973;63:878-83.

Rifkin SB, Walt G. Why health improves: defining the issues concerning "comprehensive primary health care" and "selective primary health care". Soc Sci Med 1986;23:559-66.

Riley R, Paddon P. Accidents in Canada: mortality and hospitalization. Health Reports 1989;1:23-50.

Ritchie IM, Oatman LA. Residential air pollution from kerosene heaters. J Air Pollution Control Assoc 1983;33:879-81.

Robinson E. The health of the James Bay Cree. Can Fam Physician 1988;34:1606-13.

Robinson EJ, Moffatt ME. Outbreak of rotavirus gastroenteritis in a James Bay Cree community. Can J Public Health 1985;76:21- 4.

Robitaille N, Choiniere R. An Overview of Demographic and Socio- economic Conditions of the Inuit in Canada. Ottawa: Research Branch, Corporate Policy, Indian and Northern Affairs Canada; 1985.

Romaniuk A. Increase in natural fertility during the early stages of modernization: Canadian Indian case study. Demography 1981;18:157-72.

Romaniuk A. Modernization and fertility: the case of the James Bay Indian. Can Rev Sociol Anthropol 1974;11:344-59.

Rosenthal NE, Sack DA, Carpenter CJ. Antidepressant effects of light in seasonal affective disorder. Am J Psychiatry 1985; 142:163-9.

Rubenstein A, Boyle J, Odoroff CL et al. Effect of improved sanitary facilities on infant diarrhoea in a Hopi village. Public Health Rep 1969;84:1093-7.

Rybcznski W, Polprasert C, McGarry M. Low-Cost Technology Options for Sanitation: A State-of-the-Art Review and Annotated Bibliography. Ottawa: International Development Research Center; 1978.

Ryder RW, Reeves WC, Singh N et al. The childhood health effects of an improved water supply system on a remote Panamanian island. Am J Trop Med Hyg 1985;34:921-4.

Saunders RJ, Warford JJ. Village Water Supply: Economics and Policy in the Developing World. Baltimore: Johns Hopkins University Press; 1976.

Schaller DA. Congress votes home insulation aid for low-income Indian households. Am Indian J 1976;2(12):27-28.

Schliessmann DJ. Diarrhoeal disease and the environment. Bull WHO 1959;21:381-6.

Schliessmann DJ. Atchley FO, Wilcomb MJ, Welch SF. Relation of Environmental Factors to the Occurrence of Enteric Diseases in Areas of East Kentucky. Washington, DC: US Government Printing Office; 1958. (Public Health Monograph No.54).

Schmitt RC. Housing and health on Oahu. Am J Public Health 1955; 45:1538-40.

Shapiro E. Hospital use by elderly Manitobans resulting from an injury. Can J Aging 1988;7:125-33.

Sharma RS. An epidemiological study of scabies in a rural community in India. Ann Trop Med Parasitol 1984;78:157-64.

Shkilnyk AM. A Poison Stronger Than Love: The Destruction of an Ojibwa Community. New Haven, CT: Yale University Press; 1985.

Shortt C. Providing Housing for Dependent Seniors in Native Communities [Dissertation]. Calgary: University of Calgary, 1984.

Shuval HI, Tilden RL, Perry BH, Grosse RN. Effect of investments in water supply and sanitation on health status: a threshold saturation theory. Bull WHO 1981;59(243-8):

Shy CM. Chemical contamination of water supplies. Environ Health Perspect 1985;62:399-406.

Siggner AJ. An Overview of Demographic, Social and Economic Conditions among Canada's Registered Indian Population. Ottawa: Department of Indian Affairs and Northern Development; 1979.

Silberstein S, Grot RA. Validation of models for predicting formaldehyde concentrations in residences due to pressed- wood products. J Air Pollution Control Assoc 1988;38:1403-11.

Smith SJ. Health status and the housing system. Soc Sci Med 1990; 31:753-62.

Sommer A, Woodward WE. The influence of protected water supplies on the spread of classical/Inaba and el Tor/Ogawa cholera in rural East Bengal. Lancet 1972;ii:935-7.

Spady DW. Between Two Worlds: The Report of the Northwest Territories Perinatal and Infant Mortality and Morbidity Study. Edmonton: University of Alberta, Boreal Institute for Northern Studies; 1982. (Occasional Publication No.16).

Spengler JD. Shelter for the twenty-first century. Environ Health Perspect 1990;86:281-4.

Statistics Canada. The Health and Activity Limitation Survey: Subterritorial Data for Northwest Territories. Ottawa: Statistics Canada; 1989. (Cat.No. 82-614).

Stewart WH, McCabe LJ, Hemphill EC, Decapito T. The relationship of certain environmental factors to the prevalence of Shigella infection. Am J Trop Med Hyg 1955;4:718-24.

Stocks P. The association between mortality and density of housing. Proc Roy Soc Med 1934;27:1127-46.

Stockwell EG. A critical examination of the relationship between socioeconomic status and mortality. Am J Public Health 1963; 53:956-64.

Strachan DP. Damp housing and childhood asthma: validation of reporting of symptoms. Br Med J 1988;297:1223-6.

Strachan DP, Flanningan B, McCabe EM, McGarry F. Quantification of airborne moulds in the homes of children with and without wheeze. Thorax 1990;45:382-7.

Strachan DP, Sanders CH. Damp housing and childhood asthma: respiratory effects of indoor air temperature and relative humidity. J Epidemiol Community Health 1989;43:7-14.

Stuart JM, Cartwright KA, Dawson JA et al. Risk factors for meningococcal disease: a case control study in South West England. Community Med 1988;10:139-46.

Tarshis I. The cockroach: a new suspect in the spread of infectious hepatitis. Am J Trop Med Hyg 1962;11(705-11)

Thacker SB, Music SI, Pollard RA et al. Acute water shortage and health problems in Haiti. Lancet 1980;i:471-3.

Thiessen GJ. Effects of Noise on Man. Ottawa: National Research Council of Canada; 1976. (NRC Associate Committee on Scientific Criteria for Environmental Quality No. 15383).

Thomas DK, Thompson CT. Eskimo Housing as Planned Culture Change. Ottawa: Department of Indian Affairs and Northern Development; 1972. (Northern Science Research Group, Social Science Notes 4).

Tichenor BA, Mason MA. Organic emissions from consumer products and building materials to the indoor environment. J Air Pollution Control Assoc 1988;38:264-8.

Timboni EA. Housing and health: appraisal of substandard housing. Am J Public Health 1949;39:459-61.

Traynor GW, Apte MG, Carruthers AR et al. The effects of infiltration and insulation on the source strengths and indoor air pollution from combustion space heating appliances. J Air Pollution Control Assoc 1988;38:1011-5.

Traynor GW, Girman JR, Apte MG, Dillworth JF. Indoor air pollution due to emissions from unvented gas-fired space heaters. J Air Pollution Control Assoc 1985;35:231-7.

Treaty and Aboriginal Rights Research of the Indian Association of Alberta. Water Supplies and Sanitation on Canadian Indian Reserves: A Bibliography. Ottawa: TARR; 1981.

U.S. Department of Health, Education and Welfare. Indian Health Trends and Services. [Rockville, MD]: USDHEW/PHS/HSA/Indian Health Service, Office of Program Statistics; 1978. DHEW Pub.No.(HSA)78-12009.

U.S. Department of Health and Human Services. Indian Health Service Chart Series Book. [Rockville, MD]: USDHHS/PHS/ Indian Health Service, Division of Program Statistics; 1988.

United Nations Centre for Human Settlement. The Global Strategy for Shelter to the Year 2000. Nairobi: UNCHS; 1990.

Van Zijl WJ. Studies of diarrhoeal diseases in seven countries by the WHO Diarrhoeal Disease Advisory Team. Bull WHO 1966;35: 249-61.

Victoria CG, Smith PG, Vaughan JP et al. Water supply, sanitation and housing in relation to the risk of infant mortality from diarrhoea. Int J Epidemiol 1988;17:651-4.

Villarejos VM, Pelon W, Picado B et al. Epidemiologic investigation of an outbreak of infectious hepatitis in Costa Rica. Am J Epidemiol 1966;84:457-66.

Waegemaekers M, van Wageningen N, Brunekreef B, Bolej JS. Respiratory symptoms in damp homes. Allergy 1989;44:192-8.

Waller JA. The epidemiologic basis for injury prevention. Public Health Rep 1985;100:575-6.

Walsh JA, Warren KS. Selective primary health care: an interim strategy for disease control in developing countries. N Engl J Med 1979;301:967-74.

Wambem DB, Piland NF. Effects of improved housing on health in South Dos Palos, Calif. Health Services Rep 1973;88:47-58.

Ward B. The Home of Man. Toronto: McClelland and Stewart; 1976.

Watt J, Hollister AC, Beck MD, Hemphill EC. Diarrhoeal disease in Fresno County, California. Am J Public Health 1953;43:728- 41.

Watts RR, Drago RJ, Merrill RG et al. Wood smoke impacted air: mutagenicity and chemical analysis of ambient air in a residential area of Juneau, Alaska. J Air Pollution Control Assoc 1988;38:652-60.

Waxler NE, Morrison BM, Sirisena WM, Pinnaduwage S. Infant mortality in Sri Lankan households: a causal model. Soc Sci Med 1985;20:381-92.

White GF, Bradley DJ, White AW. Drawers of Water: Domestic Water Use in East Africa. Chicago: University of Chicago Press; 1972.

Wilkins S, Reich NA, Krause CW. Organic chemical contamination in drinking water and cancer. Am J Epidemiol 1979;110:420-48.

Wilner DM, Walkley RP, Pinkerton TC, Tayback M. The Housing Environment and Family Life. Baltimore, MD: Johns Hopkins University Press; 1962.

Winslow CA. Health goals for housing. Am J Public Health 1947;37: 653-63.

Wood EW. APHA-CDC Recommended Minimum Housing Standards. Washington, DC: American Public Health Association; 1986.

Woods HM. The influence of external factors on the mortality from pneumonia in childhood and later adult life. J Hyg 1927;26: 36-43.

Woolf B, Waterhouse J. Studies on infant mortality, Part I: Influence of social conditions in county boroughs of England and Wales. J Hyg 1945;44:67-98.

World Health Organization. Appraisal of the Hygienic Quality of Housing and Its Environment. Geneva: WHO; 1967. (Tech Rep Ser No.353).

World Health Organization. Ecology and Control of Rodents of Publi Health Importance: Report of a WHO Scientific Group. Geneva: WHO; 1974. (Tech Rep Ser No.553).

World Health Organization. Environmental Health and Diarrhoeal Disease Prevention: Report of a Scientific Working Group. Geneva: WHO; 1980. (WHO/DDC/80.5).

World Health Organization. Public Health Aspects of Housing. Geneva: WHO; 1961. (Tech Rep Ser No 225).

World Health Organization. Uses of Epidemiology in Housing Programs and in Planning Human Settlements. Geneva: WHO; 1974. (Tech Rep Ser No.554).

Wotton KA, Stiver HG, Hildes JA. Meningitis in the Central Arctic: a 4-year experience. Can Med Assoc J 1981;124:887- 90.

Yassi A, Weeks J, Kraut A. Health Concerns of Hazardous Wastes. Winnipeg: Manitoba Hazardous Waste Management Corporation; 1990.

Yocom JE. Indoor-outdoor air quality relationships: a critical review. J Air Pollution Control Assoc 1982;32:500-20.

Young TK. Are subarctic Indians undergoing the epidemiologic transition? Soc Sci Med 1988;26:659-71.

Young TK. Health Care and Cultural Change: the Indian Experience in the Central Subarctic. Toronto: University of Toronto Press; 1988.

Young TK. Indian health services in Canada: a sociohistorical perspective. Soc Sci Med 1984;18:257-64.

Young TK. Mortality pattern of isolated Indians in northwestern Ontario: a 10-year review. Public Health Rep 1983;98:467-75.

Young TK, Casson I. The decline and persistence of tuberculosis in a Canadian Indian population: implications for control. Can J Public Health 1988;79:302-6.